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Annual Report
2012-13

भाकृअनुप
ICAR

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(भारतीय कृषि अनुसंधान परिषद्)
पुत्तूर–574 202, कर्नाटक

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

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प्रस्तावना

मुझे काजू अनसंधान निदेशालय, पुत्तूर की वार्षिक प्रतिवेदन 2012–13 को प्रस्तुत करने मे खुशी हो रही है। निदेशालय द्वारा अनुमोदित तकनीकी कार्यक्रम के तहत् विभिन्न परियोजनायें जो विभिन्न अवयवों जैसे फसल सुधार, फसल प्रबन्धन, फसल संरक्षण, कटाई उपरान्त प्रौद्योगिकी तथा तकनीकी हस्तांतरण के क्षेत्रों की उपलब्धियों को इस वार्षिक प्रतिवेदन में प्रस्तुत किया गया है।

राष्ट्रीय काजू जीन बैक में सग्रहित 528 जननद्रव्यो में से 473 जननन्द्रव्यों का मूल्यांकन पूरा किया जा चुका है। वर्ष 2012–13 के दौरान 21 जननन्द्रव्यों को IPGRI मानकों के अनुसार वृध्दि, उपज एव गुठली लक्षणों का मूल्यांकन किया गया है। संकरण कार्यक्रम मे 12.5 ग्राम वजन की गुठली मिली है, जिसे दुबारा मूल्यांकन की जरूरत है। पोषक तत्वों (मेग्नीशियम, जिंक एवं बोरान) के पर्णीय छिड़काव से उभयलिंगी फूलो की संख्या में बढ़ोत्तरी हुई है। पोधों को पेक्लोब्यट्राजोल से उपचारित करने से पौध वृध्दी के साथ पर्ण संधि में सकारात्मक रूप से कमी देखी गई। काजू तना एवं जड़ छेदक कीट के लिए रोगजनक सूत्रकृमि उपयोगी पाया गया तथा स्वदेशी नेमोटोड *(स्टीनरनेमा फेल्टी)* के अध्ययन की जरूरत महसूस की गई। चाय मच्छर बग के लिए रेडूवीड्स का हिंसक प्रभाव देखा गया। इनमें से कुछ प्रजातियों को आसानी से पाला जा सकता है। काजू प्रसंस्करण की ड्रम रोस्टींग पध्दति मे काजू – गुठली आकर एवं प्रांरभिक नमी काजू गिरी वसूली में असर डालती है। कटाई उपरान्त प्रौद्योगिकी कार्यक्रम में काम्पेक्ट एवं यन्त्रीकृत ड्रम रोस्टींग मशीन विकसित की गई है। जिसके प्रसंस्करण मानक बेहतर गुणवता की गिरी वसूली में अनुकूलित पाये गये है। निदेशालय में हस्तानन्तरण तकनीकी प्रयास जारी है। जो प्रदर्शन भूखण्ड स्थापित किये गये हैं, उन्हे वैज्ञानिक समूह नियमित रूप से निगरानी में रखते हैं। निदेशालय मे किसानों, कृषि विभागों और विद्यार्थियों के लाभ के लिए विभिन्न प्राशिक्षण कार्यक्रम जैसे काजू दिवस, कृषि शिक्षा दिवस आदि कार्यक्रमों का आयोजन किया गया। इसके अलावा कृषकों को उत्तम गुणवत्ता की पौध सामग्री भी उपलब्ध करायी जा रही है।

मै वर्ष 2012–13 का वार्षिक प्रतिवेदन को संकलित करने के लिए निदेशालय के सभी कर्मचारियो और संपादकीय सामिति के सदस्यो का बहुत आभारी हूँ ।

(पी. एल. सरोज)
निदेशक

स्थान : काजू अनुसंधान निदेशालय, पुतुर
दिनांक : 29 जून, 2013

PREFACE

I am glad to present the Annual Report 2012-13 of Directorate of Cashew Research, Puttur (Karnataka). As per the approved technical programme, projects in the areas of Crop Improvement, Crop Management, Crop Protection, Post-Harvest Technology and Transfer of Technology have been taken up and the progress made during the period under report has been presented.

Out of 528 accessions planted in National Cashew Field Gene Bank, evaluation of 473 accessions has been completed. During 2012-13, evaluation of 21 accessions for growth, yield and nut characters has been done as per IPGRI descriptors. Under hybridization programme, a bold nut type with 12.5 g nut weight was obtained which needs further evaluation. The foliar application of nutrients (Mg, Zn and B) indicated a significant influence on flowering and higher number of bisexual flowers. Application of paclobutrazol (PBZ) significantly influenced the plant vigour by considerably reducing the internodal length in the treated plants. The entomopathogenic nematodes (EPNs), were effective against grubs of cashew stem and root borers and an indigenous strain of EPN (*Steinernema feltiae*) was recorded necessitating further studies in this direction. The predatory role of reduviids against tea mosquito bug has been established and certain species of them could be reared successfully. The size and initial moisture content of the raw cashewnuts greatly influence whole kernel recovery in the drum roasting method of cashew processing. A compact type mechanized drum roasting machine was developed and processing parameters have been optimized for getting kernels of better quality. The Directorate continued its transfer of technology efforts and demonstration plots laid out earlier were regularly monitored by the group of scientists. The Directorate has organized various training programmes, Cashew Day, Agricultural Education Day etc. for the benefit of farmers, officials from line departments and students. Further, it has taken a major role in the production and supply of quality grafts to its clientele group.

I am thankful to all DCR staff for their contribution in overall research achievements and members of Editorial Committee for the compilation and editing of the Annual Report 2012-13.

(P.L. Saroj)
Director

Place : DCR, Puttur
Date : 29 June, 2013

CONTENTS

DCR : AN 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 Vengurle (Maharashtra). In 1971, ICAR also sanctioned All India Coordinated Spices and Cashew Improvement Project (AICS and CIP) with its Headquarters located at CPCRI, Kasaragod. The CPCRI Regional Station, Vittal (Karnataka) was given the mandate to carry out research work on cashew while four Centres under University (Bapatla, Vridhachalam, Anakkayam and Vengurle) 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 (NRCC) at Puttur on 18 June, 1986 which was upgraded and renamed by ICAR in 2009 under XI Plan as Directorate of Cashew Research (DCR). Subsequent to the bifurcation of AICS and CIP, the Headquarters of All India Coordinated Research Project on Cashew was shifted to DCR, Puttur. At present, this Coordinated Research Project is operating at 14 Centres distributed in major cashew growing areas of the country.

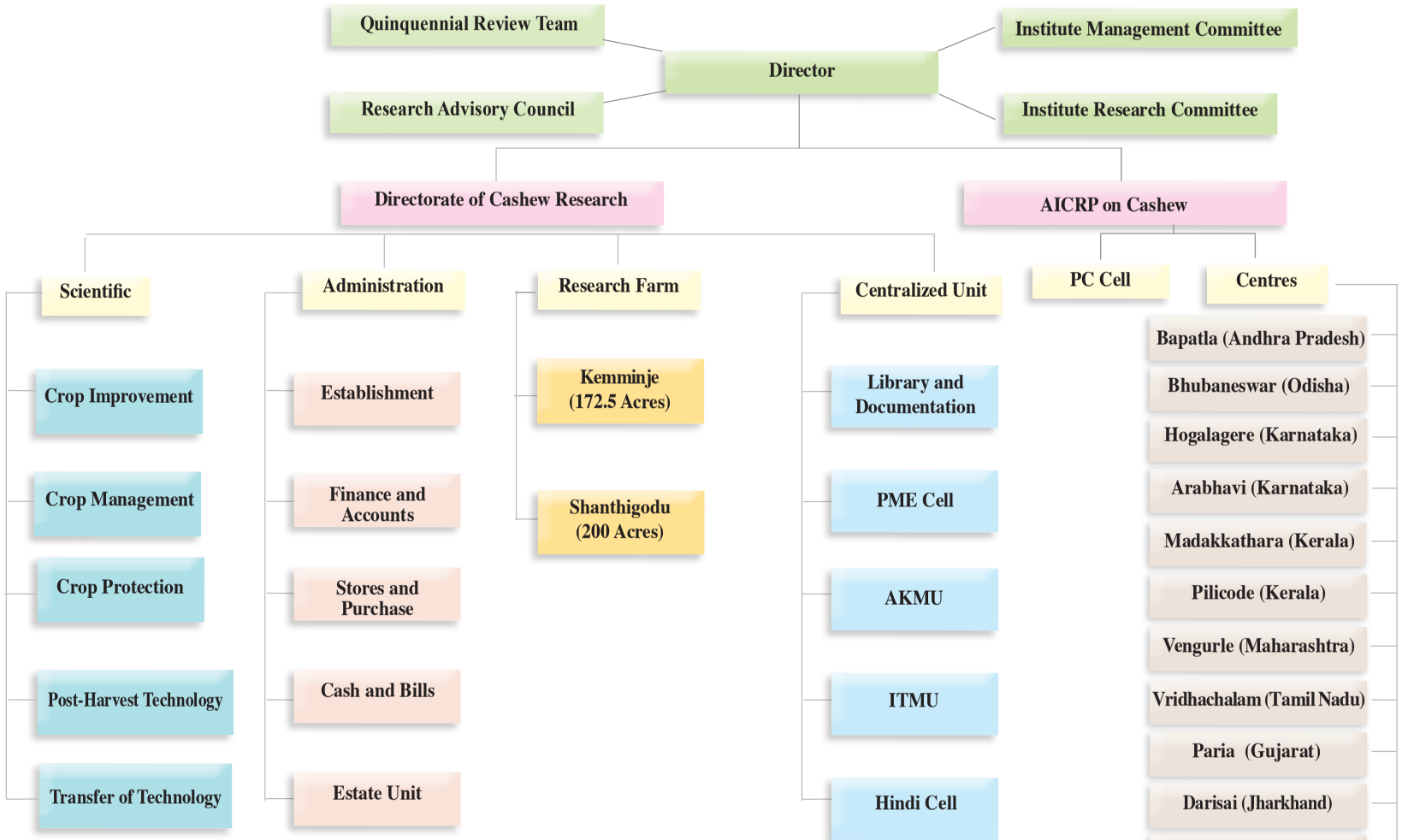
The main campus of DCR is situated 5 km away from Puttur town at Kemminje (12.45° N latitude, 75.15° E longitude and 90 m above MSL). The main campus has an area of 68 ha with field experiments and Laboratory-cum-Administrative Block. Experimental Station at Shantigodu, which also forms part of the Directorate is 13 km away from the main campus and has an area of 80 ha.

The Directorate has got well-established library in the field of cashew research. The library is serving as an Information Centre on all aspects of cashew research and development in the country. The CD database *viz.,* CABHORT, CABPEST, AGRICOLA, AGRIS, SOIL CD, CROP CD, PLANTGENE CD and TROPAG CD are also available in the library. The library has equipped with automation software and bar coding facility. The library has 1450 books and 1601 back volumes of various journals. The library subscribes 35 National and 20 International journals. The library is a member of Consortium of Electronic Resources on Agriculture (CeRA), New Delhi. Tech-Focuz digital library software is also available for CD Database search.

Mandate

- 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.

Directorate of Cashew Research



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

Organizational Structure

कार्यकारी सारांश

सन् 2012-13 मे NAIP और ICAR नेटवर्क परियोजनाओं को मिलाकर कुल 25 परियोजनाओं का कार्य निदेशालय मे सतत प्रगति पथ पर अग्रसर है। बागवानी अनुसंधान केन्द्र छतीसगढ़ से सग्रहीत जननद्रव्य को मूल्याकंन और विवेचन के लिए राष्ट्रीय काजू क्षेत्रीय जीन बैक में रोपित किया गया है। इस प्रकार निदेशालय में 528 जननद्रव्य, देश का सबसे बड़ा सग्रहण केन्द्र हो गया है। इस साल 2002-03 में रोपित 21 जननद्रव्य का मूल्याकंन IPGRI मानकों के आधार पर वृध्दि, उपज एंव गुठली लक्षणों का विवेचन सहित कुल 473 जननद्रव्यों का मूल्यांकन किया जा चुका है। संकरण कार्यक्रम के क्रास संयोजन NRC-100 x NRC-18 से बड़ी गुठली (12.5 g) मिली है। जिसे दुबारा मूल्याकंन में सम्लित किया गया है। DNA फिंगर प्रिटिंग अध्ययन से राष्ट्रीय काजू क्षेत्रीय जीन बैंक में उपस्थित जर्मप्लाज्म एकसेसन जोडीयो मे आनुवंशिक विवधता 0.10-0.92 प्रदर्शित हुई एवं औसत समानता 0.51 पायी गई। सबसे कम समानता NRC-425 और NRC-469 के बीच (0.10) पायी गई । जबकि सबसे अधिक समानता NRC-494 और NRC-491 मे (0.92) के बीच पायी गई है।

पोषक तत्वो के पर्णीय छिड़काव अध्ययन से पता चला कि पोषक तत्वों के छिड़काव से पुष्प संख्या मे सकारात्मक वृध्दि देखी गई। पोषत तत्व यूरिया + H_3PO_4 + K_2SO_4 और $ZnSO_4$ + solubor + $MgSO_4$ के संयुक्त प्रयोग से उभयलिंगी फूलों की संख्या नियंत्रण की तुलना अधिक पायी गई। जैविक उर्वरकों का मृदा में प्रयोग से मिट्टी में सूक्ष्म जीवों की संख्या मे वृध्दी देखी गई । जैविक उर्वरकों के जीवाणु पौधों के आधार के चारों ओर 45 सेन्टीमीटर की त्रिज्या मे बेक्टिरिया, फंगस, एक्ट्रीनोमाइसिटीज, नाइट्रोजन एव फास्फोरस घुलनशील बेक्टिरिया की आबादी में नियन्त्रण की तुलना में वृध्दी देखी गयी। कर्नाटक के दक्षिण कन्नड़ जिले के तीस काजू बागानों में उपलब्ध सूक्ष्म तत्वो सोडियम, कैल्सियम, मैग्नीशियम एवं बोरान की उपलब्धता का अध्ययन किया गया, अध्ययन में इन सभी तत्वों की कमी पायी गई । यह अध्ययन सूक्ष्म तत्वों के समन्वित प्रबंधन रणनिति मे मददगार साबित होगा। एक और अध्ययन से पता चला है कि काजू मे पेक्लोब्यूट्राजोल डालने से पौध वृध्दी और पर्णसंधि मे 8.8-77 प्रतिशत की कमी देखी गई। काजू तना एंव जड़ छेदक सूड़ियो पर रोगकारक सूत्रकृमि का नियंत्रण के रुप मे परीक्षण किया। जिसमे रोगजनक गोलकृमि जाति हेटरोहेबडीटीस और स्टेनेरमा उपयोगी पाये गये। कर्नाटक में काजू पारिस्तिकी तंत्र से एकत्रित मिटटी के नमूने से स्वदेशी प्रमेद स्टीनरनेमा फेलटी के लिए गहन खोज की आवश्यकता है। काजू में कोपल, पुष्पन एवं फलन अवस्था मे चाय मच्छर बग की चार स्पीसीज हेलीपेन्टीस एन्टीनी, बरेडी, थिवेरा, पेचोपेलटीस मेसरम का सक्रमण 53.81 से 100 प्रतिशत पाया गया है। काजू में कई प्रजातियाँ हेमीपटेरा, कोलियोपटेरा, लेपीडोपटेरा, थिसेनोपटेरा और आर्थोपटेरा भी बड़ी संख्या में संक्रमित करते पाये गये हैं। इस वर्ष काजू परिस्थतिक तंन्त्र से मुख्य कीट प्रभेदक रेडूवीड खोजा गया है। अब तक रेड्वीड की कुल 17 स्पीसीज को खोजा जा चुका है तथा इनका जैविक अध्ययन किपा जा रहा है। मकड़ीयो की हिसंक गतिविधि पर निगरानी जारी है अब तक कुल 46 मकड़ियो को खोजा गया है।

एक अध्ययन से पता चला है कि भारत मे 64 प्रतिशत काजू प्रंसस्करण ईकाइयाँ पूर्वी एवं पश्चिमी तट पर स्थित है। इनमें काजू प्रसंस्करण मुख्यत ड्रम रोस्टिग यंत्र के माध्यम से किया जाता है। इस मशीन से अच्छी गुणवत्ता की गिरी वसूली

के लिए कुशल मज़दूर की भूमिका अंत्यन्त महत्वपूर्ण है।

काजू के ड्रम रोस्टीग प्रसंकरण यंत्र से पूरी गिरी वसूली कर अच्छी आमादनी प्राप्त की जा सकती है। इस विधि में पूरी गिरी वसूली में गुठली आकार, नमी, फीड दर और घुमाव क्षमता प्रति मिनट आदि का भी अध्ययन किया गया है। अनुसंधान परिणामों से पता चला है कि काजू की पूरी गिरी वसूली में गुठली नमी और आकार महत्वपूर्ण भूमिका निभाते हैं। निदेशालय मे एक काम्पेक्ट ड्रम यांत्रिक मशीन विकसित करने का प्रयास जारी है। इस मशीन में विभिन्न आकार की गुठलीयो से अच्छी गुणवता की गिरी वसूली के लिए विभिन्न मानकों का मानकीकरण किया जा रहा है। इस ड्रम रोस्टींग मशीन में माल वाहक ड्रम रोस्टर, गैस बर्नर और यांत्रिक शाक्ति मशीन लगी होती है।

किसानो के खेत में पहले से प्रचालित प्रदर्शन भूखण्डों का निरक्षण और तकनाकी सलाह वैज्ञानिक समूह द्वारा दी जा रही है। निदेशालय ने किसानों को लाभान्वित करने के लिए कई कृषि मेला जैसे कृषि यंत्र मेला (विवेकानन्द इन्जिनियंरिंग कालेज पुतूर), स्वर्ण जयन्ती प्रदर्शनी, अपगला, कोडको, (भारतीय मसाला अनुसंधान संस्थान) में भाग लिया तथा वहाँ कई तरह के काजू उत्पादन और प्रस्संकरण तकनीकी के बारे सुझाव दिये । किसानों और कृषि विभागों के अधिकारियों को लाभान्वित करने के लिए निदेशालय में काजू उत्पादन तकनीकी, के साथ पुराने काजू बगीचों के जीर्णोध्दार और मृदु कलम कांड विधि के प्रशिक्षण कार्यक्रम आयोजित किये गये। 23 फरवरी 2013 को वार्षिक काजू दिवस आयोजित किया। जिसमे 200 से ज्यादा किसानों ने भाग लिया। इस वर्ष एक लाख काजू ग्राफ्टस का उत्पादन किसानों एवं कृषि विभागो में वितरण के लिए किया गया। वर्ष 2012-13 में निदेशालय से 12 शोध पत्र, 07 पुस्तक अध्याय, 08 तकनीकी लेख, तकनीकी बुलेटिन, लोकप्रिय लेख, वैज्ञानिक समीक्षा और तकनीकी लेख प्रकाशित किये गये । इनके अलावा 12 शोध पत्र विभिन्न सेमिनार एंव संगोष्टियों में प्रस्तुत किये गये। निदेशालय में शोध कार्यो की प्रभावी निगरानी के लिए समय पर बैठकों का आयोजन किया गया। हिन्दी भाषा को बढ़ावा देने के लिए हिन्दी कार्यशाला, और नगर राजभाषा कार्यान्वयन सिमिति की बैठकों का आयोजन किया गया। इस वार्षिक प्रतिवेदन में अनुसंधान परियोजनाओं के परिणाम का ब्योरा प्रस्तुत किया गया है।

EXECUTIVE SUMMARY

During 2012-13, a total of 25 projects including one NAIP project and one ICAR Network project were in operation at Directorate of Cashew Research, Puttur (Karnataka). A collection made from Horticulture Research Station, Chattisgarh was planted in gene bank block for evaluation and characterization thus raising the total holding of germplasm in National Cashew Field Gene Bank (NCFGB) to 528 which is the largest repository of cashew in the country. During the year, 21 germplasm accessions planted in 2002-03 were evaluated and characterized as per IPGRI descriptors for their growth, yield and nut characters bringing the total number of accessions evaluated to 473. In the hybridization programme, a bold nut type with nut weight of 12.5 g was obtained from the cross combination of NRC-100 x NRC-185 which will be included for further evaluation. In the DNA finger printing studies, the genetic similarity (Jaccard's) between pair of germplasm accessions maintained at NCFGB varied from 0.10 to 0.92 with an average similarity of 0.51 indicating moderate diversity among the accessions. The lowest similarity (0.10) between NRC-425 and NRC-469 suggested high genetic divergence among these accessions, while highest similarity of 0.92 between NRC-494 and NRC-491 indicated less divergence between them.

Foliar spray of nutrients significantly influenced the flowering in cashew. Higher number of bisexual flowers was obtained with combined application of urea + H_3PO_4 + K_2SO_4 and $ZnSO_4$ + solubor + $MgSO_4$ nutrients compared to the control. Soil application of bio-fertilizers had considerable influence on the soil microbial population. Inoculation of biofertilizer consortia (*Azospirillum, Acetobacter,* Phosphate solubilizing bacteria and AMF) both at tree base at a radius of 45 cm and in the rectangular trenches made in the middle of four trees resulted in higher population of bacteria, fungi, actinomycetes, N-fixers and P-solubilizers compared to the control. Thirty three cashew orchards in Dakshina Kannada district of Karnataka were tested for available S, Exch. Ca, Exch. Mg and available B contents. The results revealed a wide spread deficiency of S, Ca, Mg and B in cashew orchards, emphasizes due consideration should be given while formulating nutrient management strategies in cashew. In another study the per cent reduction in internodal length before and after application of paclobutrazol (PBZ) varied from 8.8 to 77 per cent in different treatments indicating the role of PBZ in reducing the plant vigour.

The entomopathogenic nematodes (EPN), of the genus *Heterorhabditis* and *Steinernema* were found pathogenic to the grubs of cashew stem and root borers, *Plocaederus* spp. In the soil samples collected from cashew ecosystem of Karnataka, a indigenous strain of EPN of the species, *Steinernema feltiae* was isolated and hence intensification of such exploration for identifying virulent strain is essential. Among the four species of tea mosquito bug *viz., Helopeltis antonii, H. bradyi, H. theivora* and

Pachypeltis maesarum, H. antonii was the dominant species which accounted for 53.81 to 100 per cent during flushing/flowering/fruiting stages. A large number of hemipterans, coleopterans, lepidopterans, thysanopterans and orthopterans were also found feeding on cashew. Reduviids were one of the major insect predators recorded in the cashew eco-system during the year. A total of 17 reduviid species were recorded and the biology of the important species is being studied. Monitoring of the predatory activity of spiders was continued and another 46 species were recorded in addition to the 44 species previously reported.

A total of 64 per cent of the cashewnut processing units located in east and west coast of India follow drum roasting process. Skilled labourers are required to operate the existing drum roasting machine and their coordination plays an important role in obtaining good quality end product. The whole kernel recovery during drum roasting process has strong bearing on the economics. Hence, influence of size of the nuts, moisture content, feed rate and rotation per minute of the drum roaster on whole kernel recovery was assessed. The results revealed that size and initial moisture content of the nuts play a major role on whole kernel recovery. A compact type mechanized drum roasting machine was developed and processing parameters were optimized for better kernel quality for various sized nuts. This drum roasting machine consists of material conveyor, drum roaster, gas burner and power transmission mechanism.

The Frontline demonstration plots laid out previously in the farmers' fields were monitored and technical advice was offered by the group of scientists. The Directorate participated in Krishi Yantra Mela organized at Vivekananda Engineering College, Puttur and Golden Jubilee Exhibition organized at Appangala, Kodagu by Cardamom Research Centre (Indian Institute of Spices Research) and displayed various aspects of cashew production and processing technologies for the benefit of the farmers. Training programmes on Cashew Production Technology with special emphasis on rejuvenation techniques and softwood grafting were organized for the benefit of farmers and officials from line departments. Annual Cashew Day was also organized on 23 February, 2013 in which more than 200 farmers participated. During the year, over one lakh cashew grafts were produced and distributed to farmers and Development Departments. During 2012-13, 12 research papers, 07 book chapters, 08 technical reports, one each of technical bulletin, popular article, scientific review and technical article were published. Besides, 18 papers were presented in different seminars and symposia. For effective monitoring of research and Directorate activities; the QRT, RAC and IMC meetings were organized timely. 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 on-going research projects are presented.

RESEARCH ACHIEVEMENTS

1. CROP IMPROVEMENT

1.1 Genetic resources of cashew

1.1.1 Germplasm conservation and evaluation

During 2012-13, random cashew germplasm survey was undertaken in Puttur, Sullia, Bantwal and Mangalore taluks of Dakshina Kannada district, and also in Udupi and Uttara Kannada districts. The plantations of seedling origin both in Private Sector and Karnataka Cashew Development Corporation (KCDC) were observed for locating the tea mosquito bug tolerant genotypes. A collection which was made during the previous year from HRS, Chattisgarh was planted in gene bank block for evaluation and characterization, thus raising the total holding in National Cashew Field Gene Bank (NCFGB) to 528.

Forty germplasm accessions evaluated during the earlier years were multiplied and planted in Conservation Block, NCFGB at 4 m x 4 m spacing with 4 plants of each accession as an unit.

Germplasm accessions have been evaluated for better cashew apple types based on physical and chemical quality parameters.

Twenty one germplasm accessions planted during 2002-03 were evaluated and characterized (Table 1.1). Among them, majority had upright, open with extensive pattern of branching (83.79%) and yellow red coloured with club shape young leaves (53%). Majority (57.33%) were early flowering types while, 32.0 per cent were mid season flowering and late flowering types. Nearly equal numbers were of yellow and red coloured fruit bearing types. Kernel weight was intermediate in 71 per cent with high shelling percentage. However, the cumulative yield was low in all the accessions evaluated.

Table 1.1: Important features of germplasm accessions evaluated in 2012

Data Field	Descriptor		Descriptor State	No. of Accessions
7	Tree habit	3	Upright and compact	1
		5	Upright and open	19
		7	Spreading	1
9	Leaf shape	1	Oblong	0
		2	Obovate (Club-shaped)	12
		3	Oval	9
16	Branching pattern	1	Extensive	19
		2	Intensive	2
19	Colour of young leaves	1	Red	4
		2	Yellow red	16
		3	Green red	1
		4	Purple	0

28	Season of flowering	3	Early (Nov-Dec)	13
		5	Mid (Dec-Jan)	7
		7	Late (Jan-Feb)	1
31	Mature cashew apple colour	1	Yellow	10
		2	Yellow red	11
		3	Red purple	0
		4	Red purple	0
32	Shape of cashew apple	1	Cylindrical	12
		2	Conical-Obovate	4
		3	Round	4
		4	Pyriform	1
50	Attachment of nut to cashew apple	3	Loose	8
		5	Intermediate	11
		7	Tight	2
35	Nut weight	3	Low (<5 g)	3
		5	Intermediate (5-7 g)	9
		7	High (>7 g)	9
43	Weight of cashew apple	3	Low (<27 g)	0
		5	Medium (27-52 g)	12
		7	High (>52 g)	9
60	Flowering duration	3	Short (<60 days)	2
		5	Medium (60-90 days)	19
		7	Long (>90 days)	0
62	Apple nut ratio	3	Low (<6)	5
		5	Medium (6-12)	16
		7	High (>12)	0
63	Shelling percentage	3	Low (<18 %)	0
		5	Intermediate (18-28 %)	3
		7	High (>28%)	18
64	Kernel weight	3	Low (<1.2 g)	0
		5	Intermediate (1.2-2.5 g)	16
		7	High (>2.5 g)	5
57	Shell thickness	3	Thin (<2.5 mm)	0
		5	Intermediate (2.5-4.0 mm)	21
		7	Thick (>4.0 mm)	0
65	Attachment of peel to kernel	3	Loose	9
		7	Tight	12
68	Cumulative yield per plant (6 annual harvests)	3	Low (<9 kg)	21
		5	Medium (9-18 kg)	0
		7	High (>18 kg)	0

1.2 Genetic improvement of cashew for yield and quality traits

1.2.1 Performance of promising hybrids

Among hybrids, under replicated trial, planted during 2006, the plant height ranged from 3.58 to 6.12 m, stem girth ranged from 36.08 to 53.08 cm, while the canopy spread ranged from 4.42 to 6.14 m (Table 1.2). The plant height was highest in variety Bhaskara (check) and lowest in hybrid H-1250. The stem girth was also highest in Bhaskara, while it was lowest in H-1250. The average spread of canopy was maximum in H-68 and it was minimum in H-2452. The nut yield ranged from 0.64 kg/plant (H-2452) to 3.54 kg/plant (H-68) in the third harvest.

1.2.2 Development of hybrids

1.2.2.1 Identification of hybrids from closely planted block

Three hybrids planted in 2008 at a spacing of 6 m x 6 m were found promising for nut weight and yield in the second harvest. The nut weight ranged from 8.9 to 12.5 g and yield ranged from 3.5 to 4.9 kg/plant (Table 1.3).

Table 1.2: Performance of promising hybrids

Hybrid/ variety	Plant height (m)	Stem girth (cm)	Canopy spread (m)	Yield (kg/plant)		
				2011	2012	2013
H-43	4.26	41.88	5.33	0.19	1.98	2.61
H-66	4.58	41.25	5.36	0.17	2.11	2.93
H-68	5.24	49.16	6.14	0.35	3.93	3.54
H-125	4.66	42.00	5.49	0.63	2.79	2.83
H-126	4.83	44.58	5.29	0.67	2.96	3.33
H-1250	3.58	36.08	4.95	0.17	1.88	3.24
H-2452	3.83	36.50	4.42	0.07	0.61	0.64
H-2473	4.66	48.16	6.13	0.05	1.57	2.85
NRCC Sel-2 (check)	4.45	37.88	4.76	0.24	2.17	2.99
Bhaskara (check)	6.12	53.08	5.91	0.37	3.35	2.76

Table 1.3: Performance of hybrids selected from closely planted block

Tree No.	Cross combination	Nut weight (g)	Yield (kg/plant) in the second harvest
122	NRC-99 x NRC-185	11.5	3.5
130	NRC-100 x NRC-185	12.5	4.0
163	NRC-240 x NRC-194	8.9	4.9

1.2.2.2 Crosses between popular cultivars and dwarf types

Among the hybrids generated from cross combination of popular cultivars and dwarf types, the hybrids planted in 2008, three hybrid progenies were found promising in the first harvest. These hybrids had medium to bold nut size with higher yield ranging from 2.8 to 5.4 kg/plant (Table 1.4).

Table 1.4: Performance of hybrids

Tree No.	Cross combination	Plant height (m)	Canopy spread (m)	Nut weight (g)	Yield (kg/plant)
569	Ullal-3 x NRC-492	3.6	4.35	8.0	2.8
601	Ullal-3 x NRC-492	3.5	4.50	9.8	3.0
626	Bhaskara x NRC-492	2.9	3.25	9.0	5.4

Tender fruit bunch of H-626 (Bhaskara x NRC-492)

Fruit bunch of H-601 (Ullal-3 x NRC-492)

1.2.2.3 Development of dwarf and compact cashew hybrids

A programme was initiated in 2012 to develop hybrids with dwarf and compact traits suitable for high density planting. Four popular cultivated hybrids / selections *viz.,* Vengurle-4, Priyanka, Dhana (hybrids), Madakkathara-2 (selection) as female parents and two germplasm accessions *viz.,* Brazil dwarf and Taliparmba-1 as male parents were used for this study. The details of crosses made and hybrid nuts obtained are given in Table 1.5. Reciprocal crosses involving the same parents were also made to find out any differences in the outcome and the details are given in Table 1.6.

Table 1.5: Crosses made and nuts obtained

Cross combination			Nuts obtained
Vengurle-4	x	Brazil dwarf	204
Vengurle-4	x	Taliparamba-1	151
Priyanka	x	Brazil dwarf	90
Priyanka	x	Taliparamba-1	15
Dhana	x	Brazil dwarf	63
Dhana	x	Taliparamba-1	76
Madakkathara-2	x	Brazil dwarf	171
Madakkathara-2	x	Taliparamba-1	129

Table 1.6: Reciprocal crosses made and nuts obtained

Cross combination			Nuts obtained
Brazil dwarf	x	Vengurle-4	16
Taliparamba-1	x	Vengurle-4	7
Brazil dwarf	x	Priyanka	30
Taliparamba-1	x	Priyanka	11
Brazil dwarf	x	Dhana	16
Taliparamba-1	x	Dhana	8
Brazil dwarf	x	Madakkathara-2	17
Taliparamba-1	x	Madakkathara-2	2

1.2.3 Seedling selection in cashew

An experiment was laid out in 2007 by planting the seedling progenies of NRCC Sel-2, Vengurle-4, VRI-3, Bhaskara, VTH-174, and VTH-30/4 at a spacing of 6 m x 6 m to find out the variability existing in cashew cultivars raised through seedlings. Growth parameters with respect to seedling progenies were recorded. The average plant height ranged from 4.65 to 6.19 m, the stem girth ranged from 38.43 to 52.25 cm, the canopy spread ranged from 4.61 to 5.54 m (Table 1.7). The seedling progenies of Bhaskara exhibited highest values for plant height and stem girth, while the seedling progenies of VRI-3 exhibited highest canopy spread.

1.3 Biotechnology

1.3.1 Molecular characterization of cashew

DNA was isolated from cashew varieties from Vengurle, pre-release hybrids and germplasm and used for characterizing them with both RAPD and SSR markers. In RAPD, 19 random primers were used and obtained a polymorphism of 96 per cent. Similarly, in SSR, nine primer pairs were used to characterize 32 accessions. One was monomorphic and from the remaining 8 primer pairs, 20 markers were generated out of which 18 were polymorphic (90%) (Table 1.8) with polymorphic bands ranging from 1- 4 per primer. Super fine Agarose (3%) (Amresco) was used to

Table 1.7: Performance of seedling progenies for growth characters

Variety	Plant height (m)	Stem girth (cm)	Canopy spread (m)	Yield (kg/plant) in 2012
NRCC Sel-2	4.93	38.43	4.61	0.98
V-4	5.55	48.81	5.51	1.45
VRI-3	4.65	49.25	5.54	2.32
Bhaskara	6.19	52.25	5.41	1.68
VTH-174	5.73	49.50	4.72	1.74
VTH 30/4	5.29	44.93	5.26	1.71

separate SSR bands (Fig. 1.1). Among the accessions studied, NRC-527 (Meghalaya) was highly divergent. High genetic similarity was observed between H-63 and H-65 and between V-3 and V-4. Cluster analysis with RAPD and SSR distinguished 32 accessions into 5 and 3 groups respectively.

1.3.2 Testing of SSR markers from other species and their transferability to cashew

Twenty five SSR primer pairs each from pistachio and alfalfa were procured and tested in 48 accessions of cashew and observed transferability of only 10 primers (40%) in pistachio and 3 primers (12%) in alfalfa. Using 9 SSR primer pairs of pistachio and 3 SSR primer pairs of alfalfa in 48 accessions, polymorphism of 96.3 per cent was observed. The genetic similarity (Jaccard's) between pair of accessions varied from 0.10 to 0.92 with an average similarity of 0.51 indicating moderate diversity among the accessions. The lowest similarity (0.10) between NRC-425 and NRC-469 suggested high genetic divergence with these accessions and highest similarity of 0.92 between NRC-494 and NRC-491 indicated less divergence and high genetic similarity with these accessions. UPGMA cluster analysis of 48 accessions could distinguish 9 clusters.

1.3.3 Marker assisted selection in cashew

Two F1 progenies *viz.,* Bhaskara x Taliparamba-1 and Ullal-3 x NRC-492 were studied. Both F1 progenies were phenotypically evaluated based on their growth characters (plant height, girth and lateral spread), flowering and fruiting characters. Large variability was observed in characters like plant height, fruit weight, nut weight etc. DNA was isolated from parents and F1 progeny (92) of cross Ullal-3 x NRC-492. More than 100 RAPD primers, 11 SSR primers of cashew and 9 SSR primers of other species were screened for parental polymorphism of both crosses and polymorphic markers between parents were recorded.

Table 1.8: Polymorphism in 32 accessions with SSR markers of cashew

Sl. No.	Primer code	Primer sequence 5' - 3'	No. of bands	Poly-morphic bands	% polymor-phism	Polymorphic information content (PIC)	Marker index (MI)	Band size (bp)
1.	CS-3	F-CAAAACTAGCCGGAATCTAGC R-CCCCATCAAACCCTTATGAC	2	2	100	0.366	0.732	150-160
2.	CS-7	F-GGAGAAAGCAGTGGAGTTGC R-CAAGTGAGTCCTCTCACTCTCA	3	3	100	0.207	0.620	240-280
3.	CS-8	F-GCAATGTGCAGACATGGTTC R- GGTTTCGCATGGAAGAAGAG	4	4	100	0.376	1.503	140-180
4.	CS-13	F- GCTTAGCCGGCACGATATTA R- AGCTCACCTCGTTTCGTTTC	2	2	100	0.274	0.549	160-180

5.	CS-14	F- ACTGTCACGTCAATGGCATC R- GCGAAGGTCAAAGAGCAGTC	2	1	50	0.206	0.412	190-220
6.	CS-18	F- CAGCGAGTGGCTTACGAAAT R- GACCATGGGCTTGATACGTC	3	3	100	0.119	0.358	180-200
7.	CS-19	F- GCTATGACCCTTGGGAACTC R- GTGACACAACCAAAACCACA	2	1	50	0.229	0.458	175-200
8.	CS-20	F- TGACTTTCAAATGCCACAAC R- CTCAAGCTTTCATGGGGATT	2	2	100	0.327	0.653	240-250
		Total / Mean	**20**	**18**	**90**	**0.263**	**0.661**	

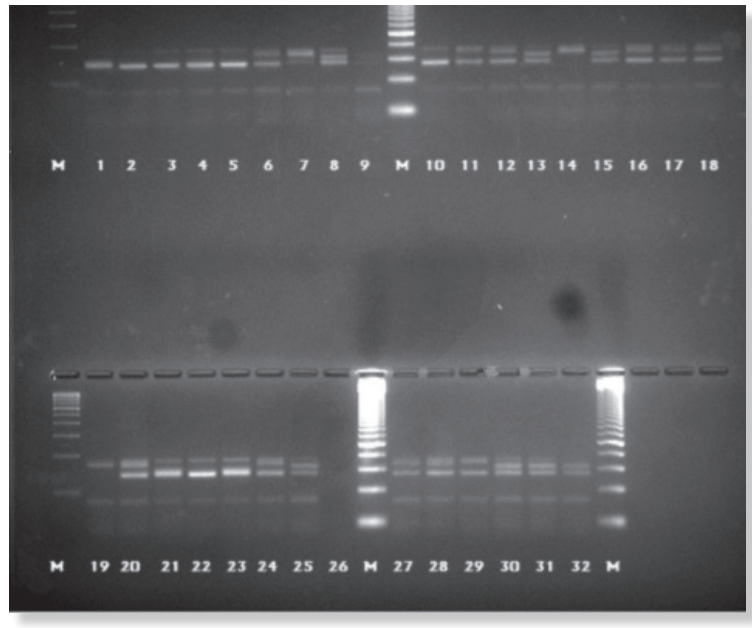


Fig.1.1: DNA profile of 32 accessions generated with CS-8 SSR primer

2. CROP MANAGEMENT

2.1 Performance of high yielding varieties of cashew

A field experiment was laid out in 2006 with nine cashew varieties *viz.,* VRI-3, NRCC Sel-2, V-7, Ullal-1, Dhana, Madakkathara-2, Ullal-3, V-4 and Bhaskara in four different spacings [200 trees/ha (10 m x 5 m), 236 trees/ha (6.5 m x 6.5 m), 384 trees/ha (6.5 m x 4 m), 500 trees/ha (5 m x 4 m)] to find out the optimum plant density for different varieties so that the recommendation can go variety-wise to achieve the highest yield and net profit for the first 10 years of orchard management under high density planting system.

The plant height ranged from 2.92 (VRI-3 planted at 6.5 m x 6.5 m) to 4.42 m (Dhana planted at 5 m x 5 m spacing). The average spread of canopy ranged from 3.13 (VRI-3 planted at 10 m x 5 m) to 4.83 m (Ullal-1 planted at 6.5 m x 4 m). The stem girth ranged from 31.17 (VRI-3 planted at 6.5 m x 6.5 m) to 53.50 m (Madakkathara-2 planted at 6.5 m x 4 m) (Table 2.1).

Table 2.1: Effect of plant densities and varieties on morphometric characteristics

Varieties	VRI-3	Ullal-3	V-4	Bhaskara	Madakka-thara-2	NRCC Sel-2	V-7	Ullal-1	Dhana	Mean
Treatments										
Plant height (m)										
S1-200	3.17	3.92	3.83	4.08	4.17	3.50	4.00	4.00	4.00	3.86
S2-236	2.92	4.17	3.83	4.08	4.08	3.83	3.67	4.00	4.25	3.88
S3-384	4.00	4.42	3.75	4.25	4.33	4.00	4.17	4.33	4.17	4.18
S4-500	3.67	4.33	3.92	4.42	4.25	3.83	4.25	4.00	4.42	4.14
Mean	3.47	4.22	3.84	4.22	4.22	3.82	4.04	4.10	4.21	
CD (Main) - NS; CD (Sub) - 0.25; CD (Main x Sub) - NS										
Canopy spread (m)										
S1-200	3.13	4.21	3.83	4.67	3.92	3.79	4.33	4.21	4.08	4.01
S2-236	3.42	3.71	3.83	3.92	4.00	3.58	4.13	3.92	4.42	3.87
S3-384	4.00	4.63	3.96	4.25	4.71	4.54	4.67	4.83	4.46	4.48
S4-500	4.13	7.54	4.00	4.25	4.13	4.21	4.50	3.88	4.08	4.15
Mean	3.65	4.18	3.97	4.20	4.19	4.04	4.39	4.39	4.19	4.29
CD (Main) - NS; CD (Sub) - 0.34; CD (Main x Sub) - NS										
Girth of collar region (cm)										
S1-200	33.50	43.83	39.00	49.00	50.50	38.50	48.50	45.17	45.25	43.69
S2-236	31.17	38.50	38.50	49.33	45.00	37.50	40.83	43.67	45.83	41.14
S3-384	39.50	48.83	40.00	48.50	53.50	43.17	47.83	53.33	50.17	47.20
S4-500	41.50	45.33	44.00	45.83	49.67	44.33	47.17	41.50	45.83	45.00
Mean	36.42	44.13	40.38	48.17	49.67	40.87	46.05	45.89	46.76	
CD (Main) - NS; CD (Sub) - 0.34; CD (Main x Sub) - NS										

2.2 Irrigation requirement of cashew

Cashew is normally grown as a rainfed crop on neglected land unsuitable for any other crop. In India, cashew experiences severe moisture stress from January to May which adversely affects its flowering and fruit set. There is a possibility of increasing the productivity of cashew by adopting high density planting system coupled with proper water and nutrient management. It was contemplated to workout irrigation requirement for cashew under different plant densities to increase the productivity of cashew. A field experiment was laid out with three different spacings as main plot treatments [5 m x 4 m (500 plants/ha), 6 m x 4 m (416 plants/ha) and 10 m x 5 m (200 plants/ha)] and six irrigation levels *i.e.,* 20% CPE, 40% CPE, 60% CPE, critical irrigation (once in 15 days), soil and water conservation technique and control (without irrigation and soil and water consrevation) as sub-plot treatments with cashew variety Bhaskara in 2011.

Drip irrigation system has been laid out as per the design. Soil samples at three different depths (0-30, 31-60 and 61-90 cm) were collected, processed and analysed for various physico-chemical and chemical properties under different plant densities. The soils were acidic in reaction (pH: 4.73 to 5.32), free of soluble salts (EC: 0.048 to 0.066 dS m^{-1}) and high in organic carbon content (1.25 to 1.49 per cent). Available N, P and K contents in surface soils ranged from 289 to 395 kg/ha, 19.3 to 32.3 kg/ha and 180 to 275 kg/ha, respectively. Exchangeable Ca and Mg content of soils varied from 1.20 to 2.25 cmol (p+)kg^{-1} and 0.95 to 1.35 cmol(p+)kg^{-1}, respectively. The major nutrients showed a decreasing trend with increase in depth of the soil. The soil moisture content during January, February and March 2013 varied from 10.5 to 14.5, 9.3 to 14.4 and 10.4 to 12.9 per cent on dry basis respectively. The height of the plant ranged from 210 to 250 cm and girth of the plant varied from 13.8 to 14.7 cm under different plant densities.

2.3 Foliar application of nutrients on cashew

This investigation was carried out during 2009-13 on nine year old cashew trees (variety NRCC Sel-2) to evaluate the effect of foliar application of major nutrients (N, P and K) and, secondary (Mg) and micronutrients (Zn and B) on cashew. Foliar spray was given at three different stages *viz.,* flushing, flowering and nut development. The treatments were as follows: I: Foliar spray of major nutrients on cashew: Urea 3%, Orthophosphoric acid (H_3PO_4) 0.5%, K_2SO_4 1%, Urea 3% + H_3PO_4 0.5%, Urea 3% + K_2SO_4 1%, H_3PO_4 0.5% + K_2SO_4 1%, Urea 3% + H_3PO_4 0.5% + K_2SO_4 1% and Control. II: Foliar spray of secondary and micronutrients on cashew: $ZnSO_4$ 0.5%, solubor 0.1%, $MgSO_4$ 0.5%, $ZnSO_4$ 0.5% + solubor 0.1%, $ZnSO_4$ 0.5% + $MgSO_4$ 0.5%, solubor 0.1% + $MgSO_4$ 0.5%, $ZnSO_4$ 0.5% + solubor 0.1% + $MgSO_4$ 0.5% and Control. Flowering was significantly influenced by foliar spray of nutrients. The maximum number of bisexual flowers was obtained with combined application of urea + H_3PO_4 + K_2SO_4 and $ZnSO_4$ + solubor + $MgSO_4$ nutrients with minimum under control (Figs. 2.1 and 2.2). No specific trend was observed in leaf area and stomatal openings under different foliar nutrition treatments (Tables 2.2 and 2.3).

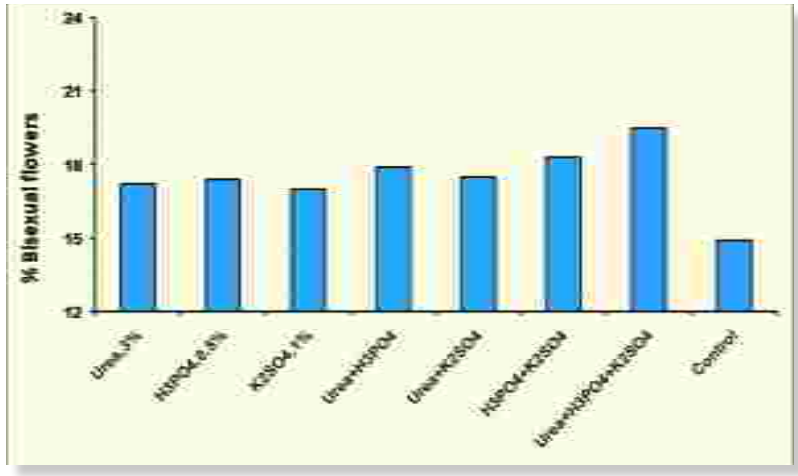


Fig. 2.1: Effect of foliar spray of major nutrients on bisexual flowers

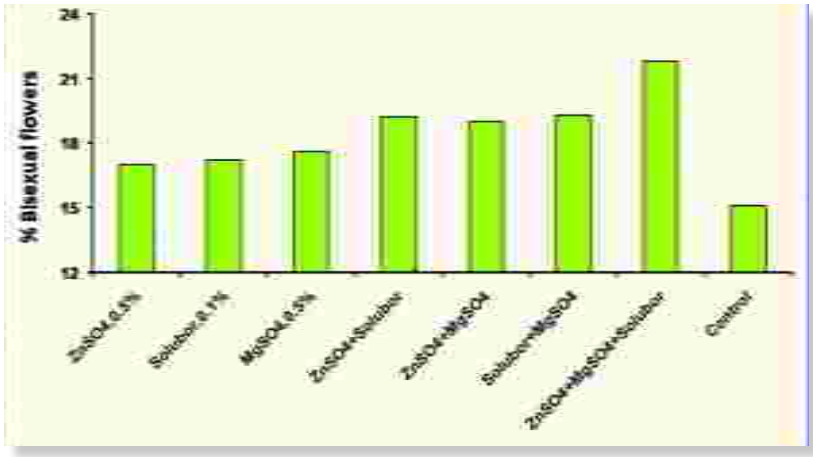


Fig. 2.2: Effect of foliar spray of secondary and micronutrients on bisexual flowers

Table 2.2: Effect of foliar spray of major nutrients on leaf area and stomatal openings

Treatment	Leaf area (cm^2)	No. of stomatal openings
Urea 3%	84.06	73
H_3PO_4 0.5%	76.72	68
K_2SO_4 1%	79.43	76
Urea+H_3PO_4	81.15	75
Urea+K_2SO_4	84.02	66
H_3PO_4+K_2SO_4	81.14	67
Urea+H_3PO_4+K_2SO_4	85.88	70
Control	85.58	72

Table 2.3: Effect of foliar spray of secondary and micronutrients on leaf area and stomatal openings

Treatment	Leaf area (cm^2)	No. of stomatal openings
$ZnSO_4$ 0.5%	83.50	68
Solubor 0.1%	89.42	72
$MgSO_4$ + 0.5%	84.63	69
$ZnSO_4$+solubor	83.40	73
$ZnSO_4$+$MgSO_4$	85.10	70
Solubor+$MgSO_4$	84.19	65
$ZnSO_4$+$MgSO_4$+ solubor	87.72	71
Control	89.17	68

2.4 Maximization of yield in irrigated cashew and sustaining soil productivity through integrated nutrient management

A field experiment was initiated in 2009 to develop a package of recommendation for young (two years old cashew variety VRI-3 during first year of study) and mature (nine years old cashew variety Bhaskara during first year of study) cashew plantations involving integrated nutrient management (INM) with the application of biofertilizers, organic manures and chemical fertilizers.

Treatments

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

M1 : Control (No inoculation)

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

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

M4 : Combination of $M_2 + M_3$

(b) Sub plot treatments (Fertilizer levels)

T1 : Control (No application)

T2 : 50 % of recommended NPK through drip + FYM

T3 : 75 % of recommended NPK through drip + FYM

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

T5 : Soil test based fertilizer recommendation through drip

*100% of recommended dose: N 135 g : P_2O_5 39 g : K_2O 34 g and FYM 5.6 kg per tree per annum.

2.4.1 Effect of INM strategies on nutrient content and microbiological properties of soil

The soil samples collected at three different depths (0-0.30, 0.31-0.60 and 0.61-0.90 m) from base of the plant at 1.5 m radius after imposing the treatments were analysed for their nutrient contents. Application of fertilizers + biofertilizers influenced the nutrient content of soil over a period of four years. The organic carbon content in different treatments ranged from 0.94 to 1.20 per cent and 0.90 to 1.08 per cent in young cashew (VRI-3) and mature cashew plantations (Bhaskara), respectively, indicating that the soils were high in organic carbon. A slight increase in organic carbon content of the soil was noted in inoculation of biofertilizer consortia both to the tree basin at a radius of 45 cm and in the rectangular trenches taken in the middle of four trees + 100% of recommended dose of nutrients (M4T4) followed by inoculation of biofertilizer consortia to the tree basin at a radius of 45 cm + 100% of recommended dose of nutrients (M2T2). The distribution of organic carbon in soils showed a decreasing trend with depth. A decrease in organic carbon content of 31.5 and 52.3 per cent was noted at 0.31-0.60 and 0.61-0.90 m soil depths respectively as compared to 0-0.30 m soil depth. High organic carbon in the surface soil could be due to litter fall and applied manure, which on decomposition is known to increase the organic matter in the soil.

Available N content in different treatments ranged from 254 to 355.9 kg/ha and 250 to 341 kg/ha in young cashew and mature cashew plantations, respectively, which falls between low to medium categories from the availability point of view. However, the available N content increased in all treatments over the initial value. The maximum

increase was observed in inoculation of biofertilizer consortia both to the tree basin at a radius of 45 cm and in the rectangular trenches taken in the middle of four trees + 100% of recommended dose of nutrients (M4T4) followed by inoculation of biofertilizer consortia to the tree basin at a radius of 45 cm + 100% of recommended dose of nutrients (M2T4). Similar trend was observed for available P (17.2 to 25.0 kg/ha and 15.2 to 23.6 kg/ha, in young cashew and mature cashew plantations, respectively), and available K (138 to 185.6 and 155.3 to 200.5 kg/ha, in young cashew and mature cashew plantations, respectively), Available P and K contents in different treatments fell between low to medium categories from the availability point of view. A consistent decrease in the concentration of available N, P and K with the increase in soil depth was noted. A decrease of 22.3 and 45.6 per cent available N, 21 and 58.2 per cent available P and 46.5 and 79.1 per cent available K was obsreved at 0.31-0.60 m and 0.61-0.90 m soil depths, respectively as compared to 0-0.30 m soil depth.

The soil samples collected after imposing the treatments were fractionated into various Zn and Cu pools *viz.,* water soluble + exchangeable Zn and Cu (CA-Zn and CA-Cu), Zn and Cu bound by inorganic sites (AAC-Zn and AAC-Cu), Zn and Cu bound by organic sites (PYR-Zn and PYR-Cu) and Zn and Cu occluded by free oxides (OX-Zn and OX-Cu). Higher content of Zn was associated in the Zn occluded by free oxides (6.60 to 15.30 mg/kg) followed by Zn bound by organic sites (4.2 to 11.90 mg/kg), Zn bound by inorganic sites (1.22 to 3.47 mg/kg) and water soluble + exchangeable Zn (0.12 to 0.31mg/kg) (OX-Zn > PYR-Zn > AAC-Zn > CA-Zn). Similarly, higher content of Cu was associated in the Cu occluded by free oxides (3.20 to 8.90 mg/kg) followed by Cu bound by organic sites (2.70 to 3.70 mg/kg), Cu bound by inorganic sites (0.15 to 0.51 mg/kg) and water soluble + exchangeable Cu (0.06 to 0.21 mg/kg). The concentration of Zn and Cu in different fractions were greater in INM treatments as compared to control (no biofertilizer inoculation and fertilizers).

The size of the microbial population in soil varied considerably with the method of biofertilizer application. Among the method of biofertilizer application, inoculation of biofertilizer consortia both to the tree basin at a radius of 45 cm and in the rectangular trenches taken in the middle of four trees (M4) followed by inoculation of biofertilizer consortia to the tree basin at a radius of 45 cm (M2) resulted in higher population of bacteria, fungi, actinomycetes, N-fixers and P-solubilizers. On an average, the population of bacteria, fungi, actinomycetes, N-fixers and P-solubilizers in M4 treatments were 7.40 and 6.96; 2.10 and 3.47; 2.33 and 2.11; 5.82 and 3.44; and 5.45 and 4.72 times higher than those in control in young cashew and mature cashew plantations, respectively (Tables 2.4 and 2.5).

2.4.2 Effect of INM strategies on growth of cashew

Data pertaining to plant height in young cashew plantation (VRI-3) revealed that it was maximum in M2T4 (512 cm), followed by M4T4 (505 cm) and M2T5 (500 cm) with minimum under control (M1T1) (444 cm). Canopy spread varied from 450 (control) to 510 cm (M4T4). The trunk girth was highest in M4T4 (45.0 cm) and lowest in control (M1T1) and M3T1 (38.5 cm). Neither method of biofertilizer application nor fertilizer levels affected growth parameters of mature cashew plantation. The average plant height in different treatments ranged from 760 to 920 cm. The trunk girth ranged from 66.0 to 81.1 cm and the canopy spread ranged from 725 to 820 cm.

Table 2.4. Soil microbial population as affected by method of biofertilizer application (Young cashew plantation, VRI-3)

Treatment	Bacteria x 10^5/g	Fungi x 10^3/g	Actinomycetes x 10^5/g	N-fixers x 10^2/g	P-solubilizers x 10^4/g
M1	14.2	16.05	20.27	8.63	4.11
M2	104.06	35.04	46.25	42.31	20.68
M3	45.6	20.2	30.89	15.85	14.50
M4	105.05	33.63	47.25	50.25	22.39

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

Table 2.5: Soil microbial population as affected by method of biofertilizer application (Mature cashew plantation, Bhaskara)

Treatment	Bacteria x 10^5/g	Fungi x 10^3/g	Actinomycetes x 10^5/g	N-fixers x 10^2/g	P-solubilizers x 10^4/g
M1	18.5	14.6	18.1	18.9	8.50
M2	120.3	40.4	33.9	62.1	30.9
M3	40.0	28.0	24.5	20.6	25.0
M4	128.9	50.7	38.3	65.0	40.1

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

2.5 Soil nutrients scenario in cashew orchards

Thirty three cashew orchards of 1 to 6 years old in Dakshina Kannada district of Karnataka were evaluated for available S, Exch. Ca, Exch. Mg and available B contents (Table 2.6). Soils at three different depths (0-30, 31-60 and 61-90 cm) were sampled from base of the plant at 1.5 m radius from each orchard. Available S content of the soils varied from 4.38 to 19.16 mg/kg, indicating 51.5 per cent of the samples were decificient. Exch. Ca and Mg ranged from 0.5 to 2.0 cmol(p^+)kg^{-1} and 0.11 to 3.25 cmol(p^+)kg^{-1}. About 30.3 and 51.5 per cent of the soils were deficient in Exch. Ca and Mg, respectively. Available B in soils ranged from 0.05 to 0.62 mg/kg, indicating 87.9% of the soils were deficient in B. There was a consistent decrease in the contents of available nutrients with the increase in soil depth. The results revealed a wide spread deficiency of S, Ca, Mg and B in cashew orchards, which emphasize due consideration while formulating nutrient strategies to cashew.

Table 2.6: Nutrient status of cashew growing soils at 0-30 cm soil depth

Sample No.	Available S mg/kg	Exch. Ca cmol(p+)kg^{-1}	Exch. Mg cmol(p^{+})kg^{-1}	Available B mg/kg
1	16.69	1.72	3.05	0.51
2	14.16	0.88	0.56	0.30
3	7.88	1.63	1.70	0.44
4	12.7	1.78	1.76	0.52
5	6.36	1.13	0.36	0.41
6	19.16	0.98	1.31	0.29
7	10.99	1.68	0.51	0.40
8	5.36	1.38	0.51	0.25
9	8.63	1.33	0.81	0.39
10	10.21	1.53	0.51	0.40
11	4.77	0.98	0.26	0.35
12	4.59	1.28	1.55	0.25
13	11.93	1.77	1.40	0.46
14	5.01	0.93	1.11	0.22
15	11.92	1.68	2.31	0.32
16	7.35	1.48	0.41	0.05
17	9.23	0.50	0.11	0.52
18	8.66	0.50	0.11	0.24
19	14.89	1.43	2.61	0.25
20	4.38	1.48	1.01	0.26
21	8.04	1.08	0.86	0.45
22	6.2	0.90	0.83	0.25
23	8.12	1.00	0.75	0.25
24	10.35	0.75	0.58	0.22
25	7.89	1.25	0.75	0.35
26	10.5	1.45	0.83	0.40
27	14.56	1.95	2.08	0.25
28	5.01	2.00	3.25	0.62
29	16.2	1.50	2.67	0.47
30	14.5	1.40	2.50	0.42
31	9.12	1.10	2.42	0.28
32	13.8	0.90	1.00	0.15
33	15	0.95	1.00	0.21
Range	4.38-19.16	0.5-2.0	0.11-3.25	0.05-0.62
Mean	10.13	1.28	1.26	0.34

2.6 Leaf nutrients status in cashew varieties

2.6.1 Leaf macronutrients

The leaf diagnosis is quite useful for the determination of nutritional status of plants. The nutritional requirement of cashew tree can differ in accordance with variety. A study was conducted to determine the nutrients concentration in the index leaf (4th and 5th leaf from tip of matured branches) of cashew varieties. Index leaf samples from sixteen cashew varieties *viz.,* NRCC Sel-2, Bhaskara, Ullal-1, Ullal-2, Ullal-3, Vengurle-1, Vengurle-3, Vengurle-4, VRI-3, Madakkathara-2, Dhana, K-22-1, Priyanka, Kanaka, VTH-30/4 and VTH-174 were collected from 10 years old trees from the experimental orchard of Directorate of Cashew Research, Puttur in June, 2011. Index leaf samples of sixteen cashew varieties were analyzed for the concentration of nutrients N, P, K, Ca, Mg, Fe, Mn, Zn and Cu (Table 2.7).

The concentration of different nutrients in leaf exhibited a wide range among the varieties. The N concentration of leaves differed significantly among 16 cashew varieties. Variety VRI-3 had the highest leaf N (1.70%) and variety Kanaka had the lowest leaf N (1.02%). Though the concentration of leaf N was the highest in VRI-3 but the reverse was true for the concentration of leaf Mg, Fe and Mn. The concentration of leaf N was more or less at par in seven varieties NRCC Sel-2, Ullal-1, Vengurle-3, Vengurle-4, K-22-1, VTH-30/4 and VTH-174. The varieties influenced the P concentration of leaves significantly. The values ranged from 0.10 to 0.15 per cent with a mean value of 0.117 per cent. The concentration of leaf P was the highest in the variety Priyanka and was the lowest in varieties Ullal-1, Vengurle-1, VRI-3 and VTH-30/4. Varieties Priyanka, Ullal-2 and Kanaka exhibited at par in the concentration of leaf P. The leaf K concentration ranged from 0.36 to 0.62 per cent with a mean value of 0.468 per cent. Leaf K was significantly higher in the varieties VTH-174 (0.62%) and Kanaka (0.60%) while, other varieties did not differ significantly. The concentration of Ca and Mg in leaf of cashew varieties exhibited a wide variation. Highest concentration of 0.45 per cent was observed in variety VTH-174 and the lowest concentration of 0.20 per cent was in variety Ullal-2. The Ca concentration of leaf was at par in VTH-174, NRCC Sel-2 and K-22-1 varieties. The concentration of Mg in leaves of cashew varied from as low as 0.14 per cent in variety Ullal-1 to as high as 0.30 per cent in variety Kanaka.

Considerable difference was noted as well, in the micronutrient concentration of leaf of cashew varieties. A relatively wide range of leaf Fe was found among the varieties. The concentration of leaf Fe was found to be statistically significant in varieties Ullal-3, K-22-1 and Dhana. Varieties differed significantly with respect to leaf Mn concentration. Higher concentration of Mn was recorded in varieties K-22-1 (33.95 mg/kg), Ullal-3 (32.69 mg/kg) and Ullal-2 (31.06 mg/kg). The concentration of leaf Zn ranged from 12.85 to 21.71 mg/kg with a mean value of 16.97 mg/kg. The variety Vengurle-1 recorded the highest concentration of 21.71 mg/kg whereas, variety Ullal-2 had the lowest concentration of 12.85 per cent. Copper concentration of the leaf ranged from 7.66 to 15.29 mg/kg with a mean of 11.53 mg/kg. Higher concentration of leaf Cu was noticed in varieties VTH-174 and Vengurle-4. The concentration of leaf Cu was not statistically significant in all the varieties except VTH-174 and Vengurle-4.

Table 2.7: Leaf nutrient content in different varieties of cashew

Variety	Macronutrients (%)					Micronutrients (mg/kg)			
	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu
NRCC Sel-2	1.68	0.12	0.46	0.43	0.26	46.56	21.30	17.87	12.56
Bhaskara	1.35	0.11	0.43	0.33	0.19	56.69	21.40	17.29	13.2
Ullal-1	1.62	0.10	0.43	0.25	0.14	48.44	21.28	17.56	11.8
Ullal-2	1.48	0.14	0.42	0.20	0.15	63.81	31.06	12.85	8.94
Ullal-3	1.10	0.12	0.55	0.35	0.24	72.71	32.69	17.25	12.8
Vengurle-1	1.51	0.10	0.41	0.21	0.20	38.17	18.21	21.71	10.0
Vengurle-3	1.64	0.11	0.47	0.22	0.18	59.79	21.37	15.37	12.62
Vengurle-4	1.69	0.11	0.43	0.30	0.25	43.50	17.09	14.56	14.06
VRI-3	1.70	0.10	0.39	0.26	0.14	34.58	12.86	16.92	13.30
Madakkathara-2	1.12	0.12	0.47	0.25	0.20	56.16	24.92	15.35	11.17
Dhana	1.50	0.12	0.53	0.23	0.18	69.23	28.86	19.01	10.10
K-22-1	1.68	0.11	0.44	0.40	0.25	71.34	33.95	16.76	8.00
Priyanka	1.57	0.15	0.47	0.21	0.27	51.45	25.28	15.53	9.95
Kanaka	1.02	0.14	0.60	0.26	0.30	48.27	20.86	15.29	7.66
VTH-30/4	1.62	0.10	0.36	0.23	0.16	46.42	16.86	16.99	13.1
VTH-174	1.65	0.12	0.62	0.45	0.23	51.56	21.69	21.25	15.29
Range	1.02-1.70	0.10-0.15	0.36-0.62	0.20-0.45	0.14-0.30	34.58-72.71	12.86-33.95	12.85-21.71	7.66-15.29
Mean	1.496	0.117	0.468	0.286	0.209	53.67	23.11	16.97	11.53
SEm	0.040	0.005	0.012	0.020	0.012	2.363	1.751	0.222	0.628
CD (p=0.05)	0.116	0.014	0.035	0.058	0.034	6.825	5.058	0.641	1.813

2.7 Rootstock studies in cashew

The different stionic combinations planted in the field were compared for various growth parameters and yield. The stionic combinations varied with respect to growth parameters. Among different stionic combinations, the plant height ranged from 3.16 (NRCC Sel-2/Taliparamba-1) to 5.11 m (Ullal-3/NRC-492). With respect to number of leaves, the values ranged from 9.17 (NRCC Sel-2/V-4) to 16.92 (V-4/NRC-492). The stem girth below the union ranged from 33.22 (NRCC Sel-2/Taliparamba-1) to 55.50 cm (Ullal-3/V-4). The stem girth above the union ranged from 28.33 (NRCC Sel-2/Taliparamba-1) to 61.66 cm (Ullal-3/V-4). The stock:scion ratio ranged from 0.90 (Ullal-3/V-4) to 1.27 (V-4 on NRC-492 as well as Taliparamba-1). The canopy spread was lowest (4.05 m) in VRI-3/Taliparamba-1, while it was highest (6.42 m) in V-4/V-4 and Ullal-3/NRC- 492. The leaf area ranged from 82.93 (V-4/Taliparamba-1) to 106.22 cm^2 (Ullal-3/NRC- 492). The internodal length was lowest (1.69 cm) in combinations, VRI-3/V-4 and VRI-3/Taliparamba-1, while it was highest (2.19 cm) in combination NRCC Sel-2/Taliparamba-1 (Table 2.8).

Table 2.8: Growth parameters and yield in different stionic combinations in cashew

Stionic combination (scion/rootstock)	Plant height (m)	No. of leaves per shoot	Girth below union (cm)	Girth above union (cm)	Stock scion ratio	Canopy spread (m)	Leaf area (cm^2)	Internodal length (cm)
Ullal-3/V-4	3.45	12.25	55.50	61.66	0.90	6.25	86.95	2.05
VRI-3/V-4	3.80	13.58	40.08	35.26	1.14	4.48	92.10	1.69
NRCC Sel-2/V-4	3.92	9.17	39.79	34.84	1.14	5.19	92.91	1.84
V-4/V-4	3.92	11.24	46.94	41.11	1.14	6.42	91.34	1.75
Ullal-3/NRC-492	5.11	11.51	50.41	42.55	1.18	6.42	106.22	1.99
VRI-3/NRC-492	4.53	14.58	45.64	39.55	1.15	5.54	84.15	1.93
NRCC Sel-2/NRC-492	4.32	13.29	43.44	39.55	1.09	5.75	83.41	1.94
V-4/NRC-492	4.34	16.92	43.86	34.30	1.27	5.18	90.28	1.85
Ullal-3/Taliparamba-1	4.69	10.62	48.25	41.63	1.15	5.33	99.00	2.00
VRI-3/Taliparamba-1	3.18	13.56	35.46	30.36	1.16	4.05	87.24	1.69
NRCC Sel-2/Taliparamba-1	3.16	16.26	33.22	28.33	1.17	4.26	87.35	2.19
V-4/Taliparamba-1	4.18	14.87	43.75	34.50	1.27	4.91	82.93	1.73
CD (p=0.05)	1.10	2.95	NS	NS	-	NS	NS	0.31

2.8 Effect of paclobutrazol on growth and yield of cashew

Paclobutrazol (PBZ) was applied @ 1, 2 and 3 g a.i. per plant as soil drench in the month of October before flushing. The frequency of application was every year, once in two years and once in three years. The observations on morphometric parameters such as flowering, fruiting and nut yield have been recorded after the imposition of PBZ.

The PBZ application reduced the plant height, canopy spread and internodal length while the number of flushes increased with the application of PBZ (Tables 2.9 and 2.10). The plant height among PBZ treated plants ranged from 229.2 to 261.1 cm in different doses and frequency of application, while in the untreated plants, plant height varied from 262.6 to 275.7 cm. The canopy spread in E-W direction among PBZ treated plants ranged from 223.7 to 252.5 cm while the untreated plants recorded 269.4 to 274.5 cm in the same direction. The canopy spread in N-S direction among PBZ treated plants ranged from 234.5 to 268.2 cm, while the untreated plants varied from 273.6 to 277.7 cm in the same direction. The girth at collar region among PBZ treated plants ranged from 28.1 to 30.0 cm, while the untreated plants recorded an average girth of 29.8 to 30.2 cm. The number of new flushes among PBZ treated plants ranged between 196 and 223, over the untreated plants (176 to 196). The internodal length in PBZ treated plants ranged from 0.6 to 3.1 cm, while the untreated plants recorded 3.4 to 3.5 cm indicating the role of PBZ in reducing the plant vigour.

Table 2.9. Effect of PBZ on plant height and canopy spread

Treatments	Plant height (cm)			Mean	Canopy spread, E-W (cm)			Mean	Canopy spread, N-S (cm)			Mean
	Every year	Once in two years	Once in three years		Every year	Once in two years	Once in three years		Every year	Once in two years	Once in three years	
PBZ @ 1g a.i./pl	237.4	244.7	261.1	247.8	251.2	246.9	247.7	248.58	242.1	268.2	255.5	255.3
PBZ @ 2g a.i./pl	229.5	241.8	256.3	242.5	223.7	252.5	239.6	238.60	235.2	248.7	253.4	245.8
PBZ @ 3g a.i./pl	229.2	240.7	259.3	243.0	237.5	248.0	238.7	241.40	234.5	253.7	252.8	247.0
Control	262.6	270.4	275.7	269.6	269.4	274.5	273.9	272.6	273.6	277.7	276.4	275.9
Mean	239.7	249.4	263.1		245.4	255.5	250.0		246.3	262.1	259.5	
Source	L	T	L x T		L	T	L x T		L	T	L x T	
SEm±	3.40	2.94	5.88		6.82	5.91	11.8		5.87	5.08	10.2	
LSD (p=0.05)	9.68	8.38	NS		19.4	NS	NS		16.7	NS	NS	

L = Level of PBZ application; T = Frequency of PBZ application

Table 2.10. Effect of PBZ on number of flushes, girth and internodal length

Treatments	Number of flushes			Mean	Girth of collar region (cm)			Mean	Internodal length (cm)			Mean
	Every year	Once in two years	Once in three years		Every year	Once in two years	Once in three years		Every year	Once in two years	Once in three years	
PBZ @ 1g a.i./pl	215	214	196	208	29.3	29.5	29.8	29.4	1.0	1.0	3.1	1.6
PBZ @ 2g a.i./pl	203	223	205	210	28.1	29.9	30.2	29.3	0.7	0.8	3.1	1.5
PBZ @ 3g a.i./pl	218	217	205	213	29.0	30.8	29.7	29.8	0.6	0.7	2.9	1.4
Control	196	182	176	184	31.2	29.8	29.8	30.7	3.4	3.5	3.4	3.4
Mean	208	209	195.5		29.4	30.0	29.9		1.4	1.5	3.1	
Source	L	T	L x T		L	T	L x T		L	T	L x T	
SEm±	9.57	8.29	16.6		0.71	0.62	1.24		0.08	0.07	0.14	
LSD (p=0.05)	NS	NS	NS		NS	NS	NS		0.23	0.20	0.40	

L = Level of PBZ application; T = Frequency of PBZ application

PBZ treated cashew plant

Untreated cashew plant

The PBZ application was found to be effective in increasing the sex ratio, number of panicles/plant while, the length and width of panicle and flowering duration got reduced (Tables 2.11 and 2.12). The number of rachis in flower panicles was unaffected by PBZ application. The sex ratio of flowers ranged from 0.17 to 0.27 per cent in treated plants while in untreated plants it was 0.15 to 0.21 per cent. The number of flower panicles per plant ranged from 53.5 to 68.4 in treated plants while in untreated plants it was 53.5 to 62.7. The length and width of flower panicles ranged from 11.6 to 17.3 cm and 16.5 to 23.3 cm respectively, in treated plants while, the untreated plants recorded 17.1 to 18.1 cm and 22.8 to 23.6 cm respectively.

Table 2.11. Effect of PBZ on sex ratio and flowering parameters

Treatments	Sex ratio			Mean	Flowering duration			Mean
	Every year	Once in two years	Once in three years		Every year	Once in two years	Once in three years	
PBZ @ 1g a.i./pl	0.22	0.21	0.17	0.20	61.4	63.4	64.8	63.2
PBZ @ 2g a.i./pl	0.26	0.24	0.18	0.23	54.2	57.4	62.8	58.1
PBZ @ 3g a.i./pl	0.27	0.25	0.19	0.24	53.6	56.2	62.0	57.3
Control	0.15	0.21	0.15	0.17	66.6	70.2	69.4	68.7
Mean	0.22	0.23	0.17		61.4	63.4	64.8	
Source	L	T	L x T		L	T	L x T	
SEm±	0.01	0.01	0.02		2.18	1.89	3.78	
LSD (p=0.05)	0.04	0.03	NS		6.22	NS	NS	

L = Level of PBZ application; T = Frequency of PBZ application

Table 2.12. Effect of PBZ on length and width of flower panciles

Treatments	Length of flower panicles (cm)			Mean	Width of flower panicles (cm)			Mean
	Every year	Once in two years	Once in three years		Every year	Once in two years	Once in three years	
PBZ @ 1g a.i./pl	16.1	16.2	17.3	16.5	20.7	20.3	23.3	21.4
PBZ @ 2g a.i./pl	12.8	15.0	17.1	15.0	17.8	19.0	20.2	19.0
PBZ @ 3g a.i./pl	11.6	13.6	17.0	14.1	16.5	17.2	20.0	17.9
Control	18.1	17.8	17.1	17.7	23.6	23.6	22.8	23.4
Mean	16.1	16.2	17.3		19.7	20.0	21.6	
Source	L	T	L x T		L	T	L x T	
SEm±	0.51	0.44	0.88		0.64	0.55	1.11	
LSD (p=0.05)	1.45	1.26	2.52		1.82	1.58	NS	

L = Level of PBZ application; T = Frequency of PBZ application

The PBZ application had increased the nut yield per plant but the weight, length, width, and volume of nut decreased (Tables 2.13 and 2.14). The PBZ treated plants recorded a nut length of 3.0 to 3.3 mm, nut width of 2.4-2.5 mm, nut weight of 6.63 to 7.56 g and nut volume of 6.84-7.74 cc while, untreated plants recorded a nut length of 3.0-3.2 mm, nut width of 2.4-2.5 mm, nut weight of 7.02-7.36 g and nut volume of 7.25-7.64 cc respectively. The average yield of treated plants ranged from 756 to 1127 g/plant while, untreated plants recorded a nut yield of 668 to 728 g/plant.

Table 2.13. Effect of PBZ on length and width of nut

Treatments	Nut length (mm)			Mean	Nut width (mm)			Mean
	Every year	Once in two years	Once in three years		Every year	Once in two years	Once in three years	
PBZ @ 1g a.i./pl	3.1	3.2	3.3	3.2	2.5	2.5	2.5	2.5
PBZ @ 2g a.i./pl	3.0	3.0	3.2	3.1	2.4	2.4	2.5	2.4
PBZ @ 3g a.i./pl	3.0	3.0	3.2	3.1	2.4	2.5	2.5	2.5
Control	3.4	3.4	3.4	3.4	2.8	2.8	2.7	2.8
Mean	3.0	3.1	3.2		2.4	2.5	2.5	
Source	L	T	L x T		L	T	L x T	
SEm±	0.02	0.02	0.04		0.02	0.02	0.04	
LSD (p=0.05)	0.06	0.05	0.10		0.06	NS	NS	

L = Level of PBZ application; T = Frequency of PBZ application

Table 2.14. Effect of PBZ on nut weight, nut volume and yield of cashew

Treatments	Nut weight (g)			Mean	Nut volume (cc)			Mean	Nut yield (g/plant)			Mean
	Every year	Once in two years	Once in three years		Every year	Once in two years	Once in three years		Every year	Once in two years	Once in three years	
PBZ @ 1g a.i./pl	7.02	7.20	7.56	7.26	7.20	7.44	7.74	7.46	809	806	756	790
PBZ @ 2g a.i./pl	6.78	6.90	7.26	6.98	7.04	7.26	7.50	7.27	1127	1090	985	1067
PBZ @ 3g a.i./pl	6.63	6.71	7.07	6.80	6.84	7.26	7.42	7.17	1031	1015	960	1002
Control	7.67	7.96	7.56	7.73	7.90	8.20	7.88	7.99	668	712	728	703
Mean	7.02	7.19	7.36		7.25	7.54	7.64		809.8	806	756	
Source	L	T	L x T		L	T	L x T		L	T	L x T	
SEm±	0.07	0.06	0.13		0.07	0.06	0.11		27.1	23.5	47.0	
LSD (p=0.05)	0.21	0.18	0.36		0.19	0.16	NS		77.3	NS	NS	

L = Level of PBZ application; T = Frequency of PBZ application

2.9 Organic farming in cashew

Increasing realization of the ill effects of long sustained, exclusive use of chemical fertilizers, and consistent growing demand from the consumers for organic cashew have fostered field experimentation in 2012 with the following treatments:

T1 : FYM to supply 500 g N/tree

T2 : FYM to supply 500 g N/tree + biofertilizer consortia*

T3 : FYM to supply 500 g N/tree + rock phosphate to supply 125 g 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.

2.9.1 Influence of organic sources of nutrients on growth parameters

The effect of various organic and inorganic sources of nutrients on growth of cashew is given in Table 2.15. The height of the plant under different treatments ranged from 128 to 164 cm. The plant girth varied from 8.67 to 10.2 cm. Canopy height of the plant ranged from 67.1 to 90.0 cm. The canopy spread ranged from 69.6 to 98.3 cm and 67.9 to 87.9 cm in N-S and E-W directions respectively. No significant difference was observed in growth parameters with respect to different treatments.

Table 2.15: Effect of different organic and inorganic sources of nutrients on growth of cashew

Treatment	Plant height (cm)	Girth (cm)	Canopy height (cm)	Canopy spread (cm)	
				E-W	N-S
T1	128	8.92	74.2	69.6	72.5
T2	135	8.83	71.7	71.7	69.2
T3	143	9.33	75.4	83.3	76.7
T4	133	8.83	80.0	80.0	69.2
T5	150	9.08	69.6	93.3	87.9
T6	164	10.2	90.0	98.3	84.2
T7	128	8.83	67.5	81.3	70.0
T8	139	8.67	77.5	71.7	72.9
T9	134	8.75	67.1	74.6	67.9
T10	151	10.0	78.8	76.7	75.0
T11	150	9.00	81.7	72.5	75.0
SEm±	7.85	0.49	5.11	7.50	6.91
LSD (p=0.05)	NS	NS	NS	NS	NS

2.9.2 Influence of organic sources of nutrients on soil and leaf nutrient status

Soil samples at three different depths (0-30, 31-60 and 61-90 cm) were collected from the base of the plant at 1.5 m radius after imposing the treatments. The soil samples were analyzed for pH, electrical conductivity, organic carbon (OC), available N, P, K, Exch. Ca and Mg (Table 2.16). The soils were acidic in reaction (pH: 5.16 to 5.97), free of soluble salts (EC: 0.014 to 0.089 dS m^{-1}), high in organic carbon in the surface soil and decreased with increasing soil depth. The soils were medium in available N, medium to high in available P and medium in available K. Surface soils were found to contain more amounts of available N, P and K than subsurface soils. Exch. Ca and Mg content of soils ranged from 0.90 to 2.10 cmol (p^+)kg^{-1} and 0.65 to 1.45 cmol(p^+) kg^{-1}, respectively. The nutrient content of index leaf is given in Table 2.17. There was no significant difference in nutrient content of leaves with respect to different treatments.

Table 2.16: Effect of different organic and inorganic sources of nutrients on soil properties

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

Table 2.17: Effect of different organic sources of nutrients on leaf nutrient content (%)

Treatment	N	P	K	Ca	Mg
T1	1.33	0.18	0.41	0.32	0.20
T2	1.27	0.16	0.43	0.35	0.19
T3	1.37	0.18	0.42	0.32	0.20
T4	1.25	0.16	0.40	0.33	0.20
T5	1.26	0.15	0.42	0.35	0.21
T6	1.34	0.16	0.39	0.34	0.19
T7	1.27	0.16	0.40	0.33	0.22
T8	1.31	0.17	0.44	0.34	0.19
T9	1.32	0.16	0.39	0.35	0.21
T10	1.35	0.17	0.40	0.33	0.22
T11	1.31	0.15	0.39	0.31	0.20
SEm±	0.061	0.011	0.025	0.021	0.009
LSD (p=0.05)	NS	NS	NS	NS	NS

3. CROP PROTECTION

3.1 Cashew Stem and Root Borers (CSRB)

3.1.1 Evaluation of various calcium salts for cocoon formation

The standardized semi-synthetic diet (SSD) was fortified with various salts of calcium *viz.,* $CaSO_4$, $CaCl_2$ and $Ca(OH)_2$ at different dosages in order to enhance the formation of normal cocoons by the CSRB grubs feeding on such SSD. It was noticed that $CaSO_4$ fortified SSD could enhance the formation of normal cocoons. Further, the cocoons formed were found to be encasing a normal pupa in case of all the Ca salts tested in comparison to the SSD which did not have addition of any Ca salt. Addition of Ca salt did not display any deleterious effect on the growth, morphology or behaviour as well as on the body weight gain by the CSRB grubs.

3.1.2 Identification of indigenously collected entomopathogenic nematode (EPN)

The soil samples of cashew ecosystem from the cashew plantations of DCR and the plantations of Karnataka Cashew Development Corporations (KCDC) at Koila, Alangar and Ramakunja in Dakshina Kannada district of Karnataka were collected during the months of August to December, 2012. The bait insects *i.e.,* larvae of wax moth *Galleria melonella* were allowed to crawl in the moistened soil samples for 12 to 24 h and were later kept aside to confirm the infection by indigenous EPN species if occurring in these cashew ecosystems.

The soil samples from DCR and KCDC indicated mortality of wax moth larvae due to infection by EPN. The wax moth larvae showed symptoms of EPN infection such as moribund condition, stiffening of the body and colour change of external integument from cream to brick red and mummification. The cadavers of such infected larvae were collected and placed for emergence of infective juveniles (IJs) of EPN using the standard water mesh method. The EPN were sent for further molecular analysis through polymerase chain reaction (PCR) technique. The DNA from EPN samples was extracted using Qia-Gen Blood and Tissue DNeasy kit by following the standard procedure provided in the kit.

PCR was carried out to detect the amplification of mitochondrial cytochrome oxidase subunit 1 (Cox1) gene by following standard protocol. The primers used were:

Primer 1 : LCO 5'GGTCAACAAATCATAAA GATATTGG-3'

Primer 2 : HCO 5'TAAACTTCAGGGTGACC AAAAAATCA-3'

Thermal cycling conditions were as mentioned below:

Step 1 : 95°C for 4 min

Step 2 : 94°C for 30 sec.

Step 3 : 45°C for 1 min 20 sec.

Step 4 : 72°C for 2 min

Step 5 : Repeat step 2, 3 and 4 for 39 times

Step 6 : 72°C for 7 min

The genomic sequences obtained were blasted following the guidelines available on the NCBI website and it was inferred that the species encountered was *Steinernema feltiae* which is a EPN species infecting sub-terranean insects.

3.1.3 Identification of chemical composition of volatile samples from cashew bark and frass

The volatiles collected through cold suction method in n-hexane and dichloromethane as solvents from fresh bark and fresh frass were analysed by GC at the analysis facility of NBAII, Bengaluru. The composition of these test materials revealed the occurrence of more compounds in dichloromethane concentrate in comparison to the n-hexane concentrate.

The volatiles were collected *in situ* for 12 h from cashew trees as well as from fresh frass (100 g) by bubbling into dichloromethane kept in ice bath. The volatile concentrates were analysed through GCMS and the compounds *viz.,* trans-2-hexanol, nonane, tetra methyl octane, hexanoic acid, tri-methyl tetradecane, 6-methyl octodecane, and dodecanoic acid; were identified from frass volatiles and the elution time ranged from 5.4 to 12.1 sec. for different compounds. The compounds identified from fresh bark were trans-2-hexanol, dodecanoic acid, trifluro-acetoxy pentadecane, and nonane which had an elution time of 5.6 to 12.2 sec. Both the samples had certain common compounds which need to be quantified for identifying kairamonal properties.

3.2 Evaluation of causes for black spot formation in cashew kernels

The raw nuts were regularly collected from various experimental plots randomly and were dissected to observe for any formation of black spots in the field condition itself. Occurrence of black spot was not observed in any of the sample collected ruling out the role of insects in formation of such spots.

3.3 Efficacy of various food grade repellents against *Ephestia cautella* in stored cashewnuts

3.3.1 Determination of oviposition repellency of various food grade repellents by free-choice method

In order to assess the oviposition repellency of various food grade repellents, treatments with clove oil and lemon grass oil at various concentrations were evaluated. Cashew kernels (100 g) were placed in large petri plates and were covered by a mosquito net cage of 1.0 m^3. The test materials *i.e.,* cashew kernels treated at 0.10, 0.05, 0.025 per cent concentration of either clove oil or lemon grass oil were placed along with a petri plate containing equal weight of untreated cashew kernels as control. Five pairs of mated moths of *E. cautella* were released into the cages and allowed for oviposition for 48 h. The samples were removed and placed in separate bottles for assessing the infestation levels due to oviposition by the moths.

3.3.2 Determination of odour staining of treated cashew kernels

The odour staining due to treatment of cashew kernels using food grade repellents for management of storage insect pest; *Ephestia cautella* indicated that the odour was persistent when the test material was used at 0.125 per cent in case of clove oil and lemon grass oil. However, the odour was not recognisable and was judged as 'kernels without odour' by all the organoleptic evaluators at the lowest dose of 0.005 per cent (Table 3.1).

Table 3.1: Testing of food grade repellents for the persistence of odour

Food grade repellents tested	Response
Whole kernels	
Clove oil 0.125%	Strong odour
Clove oil 0.075%	Medium to faint odour
Clove oil 0.005%	Normal odour
Split kernels	
Lemon grass oil 0.125%	Very strong odour
Lemon grass oil 0.075%	Strong to medium odour
Lemon grass oil 0.005%	Normal to faint odour
Whole kernels	
Clove oil 0.125%	Strong odour
Clove oil 0.075%	Medium to faint odour
Clove oil 0.005%	Normal odour
Split kernels	
Lemon grass oil 0.125%	Strong odour
Lemon grass oil 0.075%	Medium odour
Lemon grass oil 0.005%	Normal odour
Whole kernels-untreated	Normal odour
Split kernels-untreated	Normal odour

3.4 Tea Mosquito Bug (TMB)

3.4.1 Screening of cashew varieties against TMB

The screening of the varieties against the incidence of TMB was continued during this year. The damage due to the infestation of pest was recorded in 0-4 scale from November, 2012 to March, 2013 (Grade 0 = no damage, 1=1-3 necrotic lesions, 2=4-6 coalescing lesions, 3=>6 coalescing lesions and 4=complete drying). The incidence of TMB in different varieties is shown in Fig. 3.1. The incidence of TMB was lower in Ullal-1 and Dhana with a mean damage score of 0.09 and 0.11, respectively. This was followed by Bhaskara (0.17). The incidence was higher in Vengurle-7 (0.64), Ullal-4 (0.71) and NRCC Sel-2 (1.64).

3.4.2 Incidence of TMB in trees with foliar spray of nutrients

3.4.2.1 Foliar spray of major, secondary and micronutrients

The treatments were I: Foliar spray of major nutrients on cashew: Urea 3%, Orthophosphoric acid (H_3PO_4) 0.5%, K_2SO_4 1%, Urea 3% + H_3PO_4 0.5%, Urea 3% + K_2SO_4 1%, H_3PO_4 0.5% + K_2SO_4

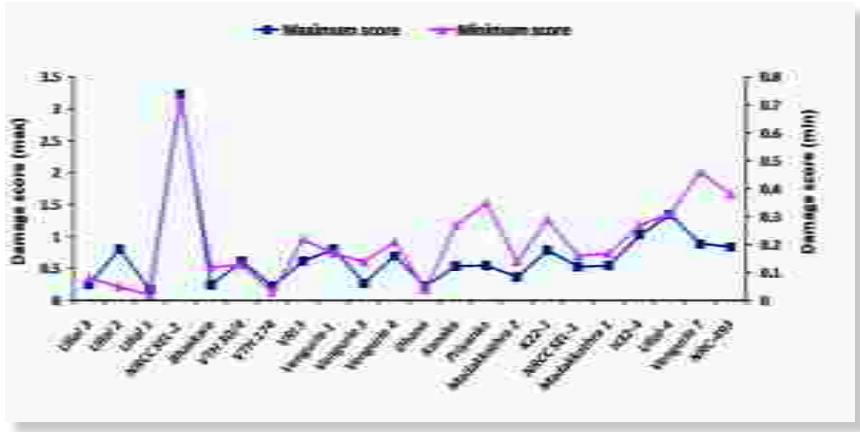


Fig 3.1: Mean damage score of 22 cashew varieties against TMB

1%, Urea 3% + H_3PO_4 0.5% + K_2SO_4 1% and Control. II: Foliar spray of secondary and micronutrients on cashew: $ZnSO_4$ 0.5%, solubor 0.1%, $MgSO_4$ 0.5%, $ZnSO_4$ 0.5% + solubor 0.1%, $ZnSO_4$ 0.5% + $MgSO_4$ 0.5%, solubor 0.1% + $MgSO_4$ 0.5%, $ZnSO_4$ 0.5% + solubor 0.1% + $MgSO_4$ 0.5% and Control. The foliar spray of nutrients were given at flushing, flowering and nut development stages.

The incidence of TMB was lower in K_2SO_4 1% sprayed trees with a mean damage score of 0.50. In untreated control the damage score was 1.33 (Fig. 3.2). The incidence of TMB was lower in solubor (0.1%) sprayed trees with a mean damage score of 0.72. In untreated control the incidence of TMB was higher with a maximum of 1.28 (Fig. 3.3).

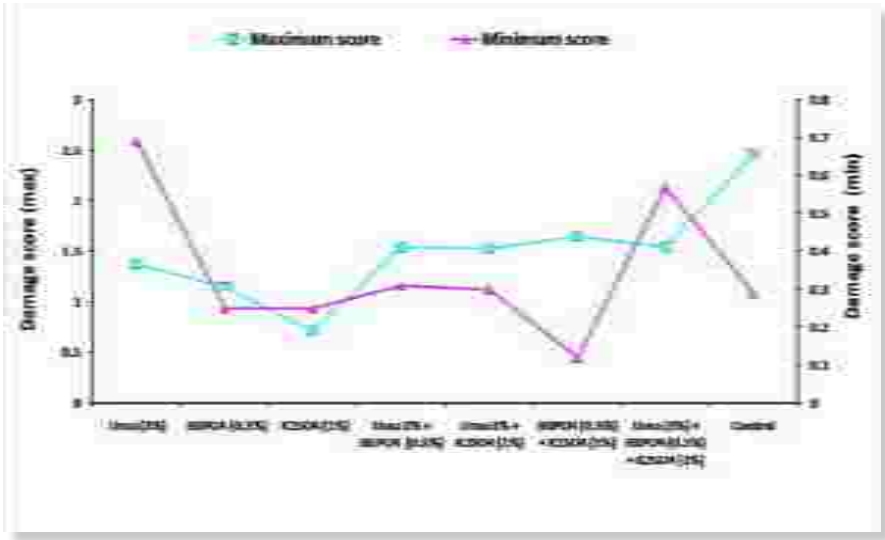


Fig. 3.2: Foliar spray of major nutrients on TMB incidence

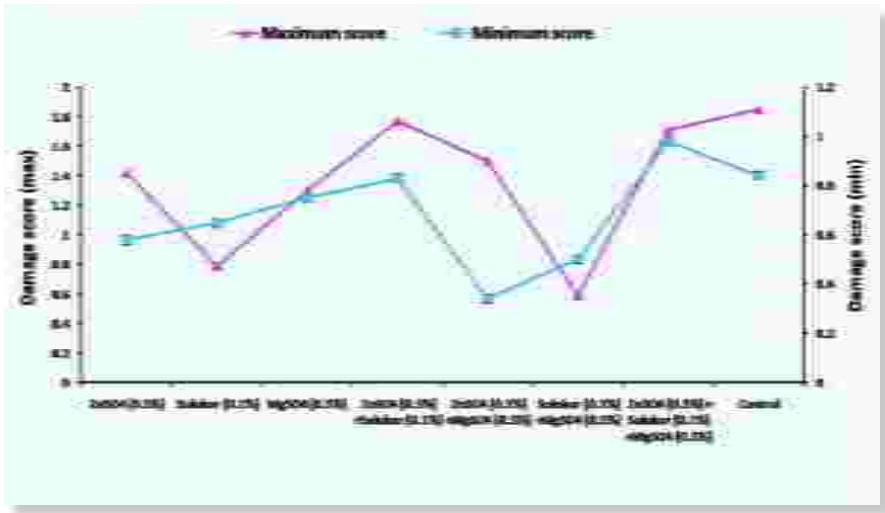


Fig. 3.3: Foliar spray of secondary and micronutrients on TMB incidence

3.5 Bio-diversity of arthropod fauna in cashew eco-system

3.5.1 Documentation of insect pests associated with cashew

Four species of tea mosquito bug *viz., Helopeltis antonii, H.bradyi, H.theivora and Pachypeltis maesarum* was observed in the cashew plots of DCR, Puttur during April, 2012 -March 2013. *H. antonii* was the dominant species which accounted for 53.81 to 100 per cent (Table 3.2) of the TMB population during different months of observation. The damage due to TMB infestation was more than 50 per cent in several instances during this period.

Table 3.2: Incidence of tea mosquito bug during 2012-13

Month	*H. antonii*	*H. bradyi*	*H. theivora*	*P. maesarum*
April, 2012	83 (100)	0.00	0.00	0.00
May, 2012	183 (100)	0.00	0.00	0.00
June, 2012	81 (100)	0.00	0.00	0.00
July, 2012	38 (90.48)	1 (2.38)	0.00	3 (7.14)
August, 2012	22 (95.65)	0.00	0.00	1 (4.35)
September, 2012	18 (60.00)	0.00	2 (6.67)	10 (33.33)
October, 2012	81 (63.28)	29 (22.66)	13 (10.16)	5 (3.91)
November, 2012	206 (84.77)	30 (12.35)	4 (1.65)	3 (1.23)
December, 2012	226 (53.81)	126 (30.00)	62 (14.76)	6 (1.43)
January, 2013	210 (92.86)	70 (21.60)	44 (13.58)	0.00
February, 2013	130 (92.86)	8 (5.71)	0.00	1 (1.43)
March, 2013	132 (99.25)	0.00	0.75	0.00

Figures in the parentheses indicate the percentage values

Other pests noticed include a number of hemipterans, thysanopterans orthopterans coleopterans, lepidopterans etc., which are given in Table 3.3. Among these pests, cashew stem and root borer, leaf miner, shoot tip caterpillar and apple and nut borers are found to cause considerable damage.

Table 3.3: Arthropod fauna other than TMB recorded during 2012-13

Sl. No.	Common Name	Scientific name	Family	Plant part affected	Period of occurrence
Order: Hemiptera					
1	Spittle bug	*Eurybrachis tomentosa*	Fulgoridae	Shoot	December-February
2	Mealy bug	*Planococcus* sp.	Pseudococcidae	Leaf, panicle and fruit	November-January
3	Hopper	*Amrasca biguttula*	Cicadellidae	Shoot and leaf	September-March
4	Gundhi bug	*Leptocorisa acuta*	Alydidae	Shoot	December-March
5	Scale insect	*Ceroplastes rubens* Maskell	Coccidae	Leaf	Throughout the year
6	Tallow stink bug	*Erthesina fullo*	Pentatomidae	Shoot	October-March
7	Man faced bug	*Catacanthus incarnatus*	Pentatomidae	Shoot, immature fruits and nuts	February
Order: Thysanoptera					
8	Red banded Thrips	*Selenothrips rubrocinctus* Giard	Thripidae	Leaf	January-March
9	Leaf thrips	*Retithrips syriacus* Mayet	Thripidae	Leaf and fruits	February
Order: Orthoptera					
10	Long horned Grass hopper	*Conocephalus* sp.	Tettigonidae	Leaf and shoot	Throughout the year
Order: Coleoptera					
11	Red pumpkin beetle	*Aulacophora atripennis* (F.)	Chrysomelidae	Leaf	January-March
12	Tortoise beetle	*Aspidomorpha* sp.	Chrysomelidae	Leaf	Throughout the year
13	Fruit beetle	*Carpophilus* sp.	Nitidulidae	Apples	February-March
14	Cashew stem and root borer	*Plocederus ferrugenius, P. obesus* and *Batocera rufomaculata*	Cerembycidae	Stem and root	Throughout the year
15	Bentid weevil	*Schizotrachelus intermedius*	Brentidae	Trunk	September-February
Order: Lepidoptera					
16	Bag worm	*Clania* sp.	Psychidae	Leaf	Throughout the year
17	Leaf roller	*Caloptilia tisilea*	Tortricidae	Leaf	November-December
18	Hairy caterpillar	*Euproctis subnotata*	Lymantridae	Leaf and panicle	November-January
19	Diamond hairy caterpillar	*Metanastria hyrtaca Cramer*	Lasiocampidae	Leaf and panicles	November-January
20	LBW	*Lamida moncusalis* Walker	Pyralidae	Leaf and panicle	November-February
21	Leaf webber	*Orthaga exvinacea* Hampson	Noctuidae	Leaf and shoot	December
22	Leaf webber	*Dudua aprobola*	Tortricidae	Leaf	November-March

23	Looper	*Hypisidra infixaria*	Geometridae	Leaf	November-December
24	Brown looper	*Chilkasa* sp.	Geometridae	Leaf	November-January
25	Looper	*Oenospila flavifuscata* Walker	Geometridae	Leaf	November
26	Tobacco cut worm	*Spodoptera litura* F.	Noctuidae	Leaf	November
27	Shoot tip caterpillar	*Chelaria haligramma* Meyrick	Gelechiidae	Shoot	November-March
28	Apple and nut borer	*Thylacoptila paurosema*	Pyralidae	Immature - ripe fruits and nuts	January-March
Order: Diptera					
29	Fruit fly	*Drosophilla* sp.	Drosophilidae	Ripe fruits	January-March
Order: Isoptera					
30	Termite	*Odontotermus* sp.	Termitidae	Trunk and root	Throughout the year

Incidence of *Catacanthus incarnatus* Dru. (*Heteroptera: Pentatomidae*) : A pentatomid bug, *Catacanthus incarnatus* (Heteroptera: Pentatomidae) caused pronounced damage on cashew tender apples during fruiting season. The wings of this bug are membranous but hardened or leathery at the base and are held flat against the body. These bugs have a prominent scutellum with two paired black spots at the top, besides a prominent black patch on both wings. The entire arrangement makes it appear like a face of a man and hence known as 'man faced bug'. The bugs were found on young as well as ripped cashew apples. On an average, 6-9 adult bugs were observed feeding on a single panicle with fruits. Around 300 bugs were recorded on a single cashew tree. The bug preferred the very young fruit followed by ripe fruits and tender shoots. The bugs first hovered around the bunch of fruits in order to select suitable site for feeding and then started sucking the juice by thrusting their long pointed stylet. As soon as stylet of the bug was withdrawn, the resin and sap oozed out through the feeding punctures.

Aggregation of *C. incarnatus* on cashew apple bunch

Probing on cashew apple

3.5.2 Documentation of natural enemies of insect pests of cashew

Documentation of natural enemies of insect pests was made in the cashew plots of DCR, Puttur during April, 2012 - March, 2013. Reduviids were one of the major insect predators recorded in the cashew eco-system during the year. A total of 17 predators were recorded the activity of which was noticed all round the year (Table 3.4)

Table 3.4: Reduviids recorded in the cashew eco-system

Species	Months of occurrence
Alcmena sp.	June-August
Biasticus sp.	March-May
Cydnocoris gilvus Burmeister	December-March
Endochus albomaculatus Stal	June-August
Endochus sp.	July-August
Epidaus bicolor Distant	November-March
Epidaus sp.	February
Euagoras plagiatus Burmeister	January-May
Irantha armipes Stal	October-November
Lanca sp.	December-March
Panthous bimaculatus Distant	January-December
Rhynocoris fuscipes Fabricius	June-August
Rihirbus trochantericus Stal var. sanguineous	November
Rihirbus trochantericus Stal var.luteous	August-October
Scadra sp.	June-July
Sphedanolestes signatus Distant	December-March
Sycanus galbanus Distant	November-April

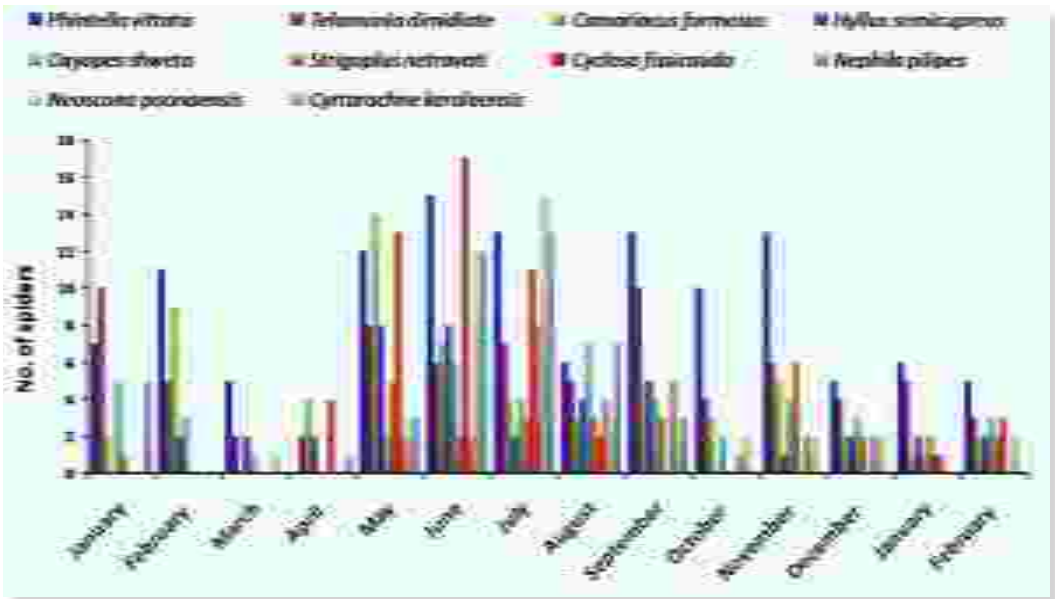


Fig. 3.4: Seasonal incidence of 10 species of predominant spiders

The monitoring of the predatory activity of spiders was continued and another 46 species were recorded in addition to the 44 species previously reported (Table 3.5 and Fig. 3.4).

Table 3.5: Spiders recorded in the cashew eco-system

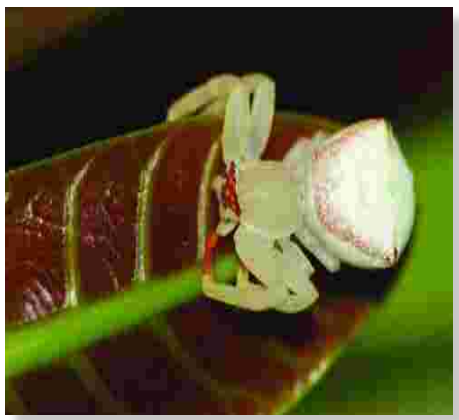
Family	Scientific name	Common name
Araneidae	*Arachnura feredayi* L. Koch	Scorpion-tailed spider
	Araneus nympha Simon	#
	Cyclosa fissicauda Simon	#
	Cyrtophora citricola Forsskal	Jungle tent web spider
	Cyrtophora unicolor Doleschall	Garden tent web spider
	Eriovixia laglazei Simon	Grey bird dropping spider
	Parawixia dehanii Doleschall	Abandoned web spider
	Thelecantha brevispina Doleschall	False gasteracantha
Clubionidae	*Clubiona* sp.	Patchy sac spider
	Matidia sp.	#
Corinnidae	*Castianeira zetes* Simon	Black-ant mimicking spider
Gnaphosidae	*Drassodes* sp.	#
	Poecilochroa sp.	#
	Scotophaeus sp.	#
Hersilidae	*Hersilia savignyi* Lucas	Two tailed spider
Lycosidae	*Hippasa* sp.	#
Linyphiidae	*Lynyphia striata* sp.nov.	Stripped linyphid spider
Miturgidae	*Cheiracanthium melanostomum* Thorell	Yellow sac spider
Nephilidae	*Nephila* sp.	#
	Nephila pilipes Simon	Giant wood spider
	Herennia multipuncta Doleschall	Ornamental tree trunk spider
	Herennia sp.	Ornamental tree trunk spider
Pholcidae	*Pholcus* sp.	Long- bodied cellar spider
	Uthinia atrigularis Simon	Leaf-dwelling pholcid
Pisauridae	*Perenethis venusta* L. Koch	Single stripped grass spider
Salticidae	*Carrhotus viduus* CL Koch	Black and white jumper
	Epeus tender Simon	Orange crested jumper
	Myrmarachne sp.	#
	Myrmarachne sp.	#
Tetragnathidae	*Leucauge decorate* Blackwall	Three-humped leucauge spider
	Leucauge sp.	#
	Leucauge pondae Tikader	Pond leucauge spider
	Opadometa fastigata Simon	Humped silver spider
	Tetragnatha fletcheri Gravely	#
Theridiiae	*Achaearanea mundula* L Koch	Rolled leaf spider
	Argyrodes ambalikae Tikader	#
	Argyrodes argentatus OP Cambridge	Quick-silver spider
	Argyrodes gazedes Tikader	Parasitic comb-footed spider
	Argyrodes sp.	#
	Ariamnes flagellum Doleschall	Whip spider
Thomisidae	*Amyciaea forticeps* O P Cambridge	Red ant spider
	Strigoplus netravati Tikader	Grass crab spider
	Thomisus lobosus Tikader	White crab spider
	Thomisus pugilis Stoliczka	Common rose spider
	Xysticus minutes Tikader	Brown crab spider
Uloboridae	*Miagrammopes extensus* Simon	Twig spider

common name not available



Chrysso argyrodiformis *Oxyopes shweta* *Telamonia dimidiate*

Spider predation on tea mosquito bug



Thomisus pugilis

Epocilla aurantiaca

Amyciaea forticeps

Hersilia savignyi

The general predatory fauna observed are an array of spiders, ants, reduviids and a few praying mantises, coccinellids, syrphids and green lace wing (Fig. 3.5).

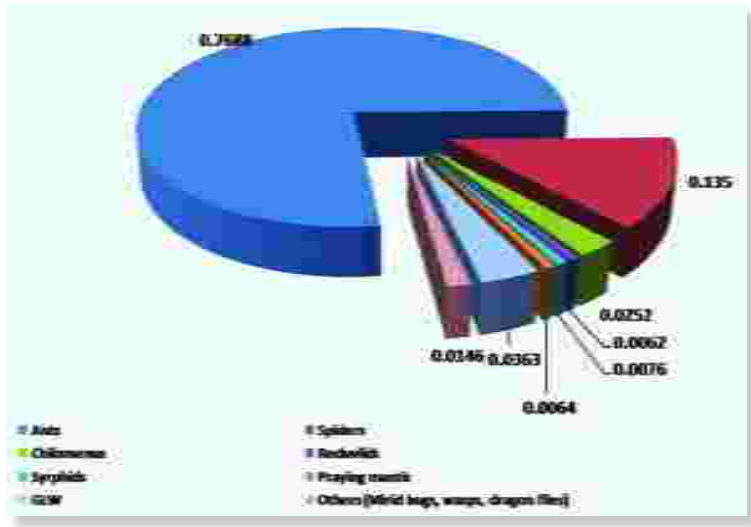


Fig. 3.5. The proportion of predators of cashew pests recorded during 2012-13

Green lace wing (*Chrysoperla zastrowi silemi*) (carnea) eggs under a cashew leaf

***Tetraponera rufonigra* - A predatory ant**

3.5.3 Biology of reduviids

Reduviid species are recorded as indigenous natural enemies of tea mosquito bug (*Helopeltis* spp). The biology of reduviids worked out (Table 3.6). The eggs were laid singly as well as in groups up to 26 eggs in 3 to 7 clusters per female. The incubation period was 13.00 ± 0.69 days. The stadial durations of I, II, III, IV and V nymphs were 12.39 ± 1.13, 7.00 ± 0.39, 7.56 ± 0.35, 9.28 ± 0.64 and 12.78 ± 1.27 days, respectively. Adult males and females survived for 107.13 ± 2.70 and 117.9 ± 3.83 days, respectively and their sex ratio was 1:0.67. The reduviid predated in a sequential pattern: arousal - approach - capturing - probing - piercing and sucking.

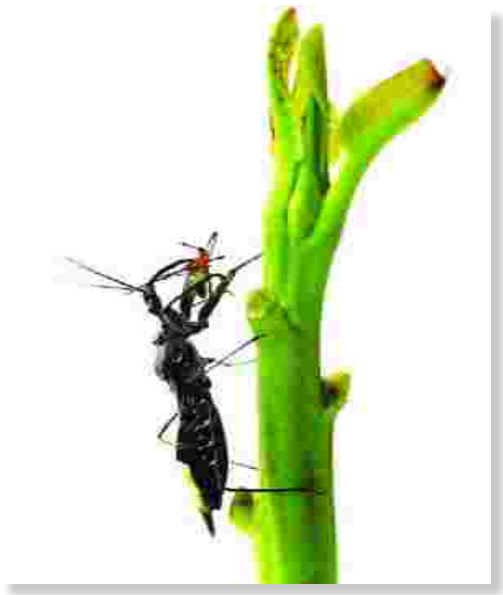
Table 3.6: Biological parameters of *R. trochantericus* on wax moth larvae under laboratory conditions (n= 47; x ± SE)

Parameters		(in days)
Incubation period (days)		13.00 ± 0.69
Stadial period (days)	I instar	12.39 ± 1.13
	II instar	7.00 ± 0.39
	III instar	7.56 ± 0.35
	IV instar	9.28 ± 0.64
	V instar	12.78 ± 1.27
	I-V instars	49.00 ± 2.48
Total stadial period (days)	Male	46.13 ± 2.35
	Female	51.30 ± 4.02
Fecundity/female (no.)		67.50 ± 15.01
Hatchability (%)		78.89
Survival rate (I-V) (%)	40.00	
Sex ratio (female:male)	1:0.67	
Pre-oviposition period (days)	17.88 ± 0.72	
Oviposition period(days)	34.62 ± 3.49	
Post-oviposition period (days)	9.75 ± 0.70	
Adult longevity (days)	Male	61.00 ± 3.12
	Female	66.6 ± 5.73
Total longevity	Male	107.13 ± 2.70
	Female	117.9 ± 3.83

The functional response of *R. trochantericus* was assessed separately at six different prey densities *viz.,* 1, 2, 4, 6, 8 and 10 prey/predator of both wax moth larvae and its natural prey, TMB for 5 days in rearing glass bottles (500 ml). R. *trochantericus* responded to increasing prey density of wax moth larvae and TMB by killing more prey than at lower prey densities.

3.5.4 Bio-systematicc of reduviids

The molecular identification of reduviids was based on the core principle of generating DNA barcode using mitochondrial cytochrome c oxidase 1 (COX1) gene. Total DNA was isolated from individual reduviids *viz., Alcmena* sp., Cydnocoris gilvus Burmeister, *Endochus albomaculatus* Stal, *Endochus* sp., *Euagoras plagiatus* Burmeister, *Lanca* sp., *Panthous bimaculatus* Distant and *Rihirbus*



***R. trochantericus* predating on TMB**

trochantericus Stal var. luteous by modified CTAB method. A part of the specimen was ground with 1 ml of 2% cetyl trimethyl ammonium bromide (CTAB), 100 mM Tris-HCl (pH-8.0), 1.4 M sodium chloride, 20 mM EDTA and 2% of 2-mercaptoethanol. The suspension was incubated at 65°C for 1-2 h and then an equal volume of chloroform: isoamyl alcohol solution was added. The suspension was centrifuged at 6000 rpm for 15 minutes. The aqueous layer was transferred to the fresh 2 ml micro centrifuge tube taking care not to disturb the middle protein interface. DNA was precipitated by the addition of 20 µl of 0.3 M sodium acetate and equal volume of ice- cold 95% ethyl alcohol. The precipitated DNA was spun at 8000 rpm for 10 minutes and the resultant DNA pellet was washed with 70% ethyl alcohol. This was centrifuged at 8000 rpm for 10 minutes and finally the pellet was dissolved in 50 µl DNase, RNase free molecular biology water. The genomic DNA was visualized using 1% agarose gel and diluted with sterile water to get a working solution of 20-25 ng/µl.

Polymerase chain reaction (PCR) was carried out in a thermal cycler (AB-Applied Biosystems) and the universal primer specific to mitochondrial cytochrome oxidase I (COX-I) used for the amplification resulted in approximately 700 bp fragment. The amplified product was resolved in 1% agarose gel and the remaining PCR product was eluted using Nucleospin Extract II which is sequenced in an automated sequencer using M13 universal primer. The sequences were submitted in NCBI database.

4. POST-HARVEST TECHNOLOGY

4.1 A value chain on cashew for domestic and export market (NAIP)

4.1.1 Maturity standards of raw cashewnuts

Grade standards identify the degree of quality in a commodity that is basis of its usability and value. Raw cashewnuts of two different varieties *viz.,* Bhaskara and Ullal-3 harvested at various stages of maturity *i.e.* 10, 20, 30, 40 and 50 days after fruiting (DAF), and full maturity, were used in the present investigation. Based on the spatial dimensions of the individual nuts, equivalent diameter and sphericity were worked out. Moisture content and individual nut weight were also determined in order to find out the changes during its maturity. The nut weight decreased from 8.56 to 4.80 g in Ullal-3 variety and from 11.36 to 5.54 g in Bhaskara variety primarily due to loss of moisture during the nut growth phase.

Average values of equivalent diameter and sphericity decreased from 25.86 to 21.56 mm and 77.81 to 77.12 per cent for Ullal-3 variety, whereas in Bhaskara variety, values recorded also showed decreasing trend *i.e.* equivalent diameter from 28.72 to 22.21 mm and sphericity from 74.32 to 71.56 per cent. Significant change in the equivalent diameter clearly indicates that nut hardening takes place while growing from pea nut stage (10 DAF) to full maturity (Ripened fruit). Therefore hardness of the nut could be considered while assessing the quality of raw cashewnuts.

Using light reflectance values in terms of L, a and b, changes in the surface colour characteristics was found out. Considering raw cashewnuts at pea nut stage as standard, changes in the surface colour (ΔE) were worked out. Values of ΔE ranged from 1.11 to 113.41 and 3.51 to 107.42 for Bhaskara and Ullal-3 varieties respectively indicating that change in the surface colour has negligible variation during nut formation towards maturity *i.e.* change of green colour to greyish brown. Therefore surface colour could serve as a quality parameter to evaluate nut quality irrespective of the variety.

Cutting energy and peak force were determined for the raw cashewnuts of selected varieties in different orientation *viz.,* concave, convex, apex and stem end using textural profile analyzer. Cutting energy found to be in the range of 0.82 to 5.33 kg-mm and 2.79 to 15.10 kg-mm for Bhaskara and Ullal-3 varieties respectively irrespective of orientation in which uni-axial compression force was applied. As far the nut orientation is concerned, concave or convex side required higher energy than stem or apex end for the varieties investigated. Total contact area available for compression force applied through the BSK blade with 45° bevel angle could be underlying factor. Peak force observed to be high for Bhaskara than Ullal-3 variety and recorded highest value of 45.42 in the convex direction. Data generated could be used for designing an appropriate tool to adjudge the maturity of raw cashewnuts indicating quality, based on cutting force.

4.1.2 Moisture sorption characteristics of cashew kernels

Using humidity chamber cashew kernel samples (white wholes and splits) were exposed to various environment generated in terms of air temperature (25, 30 and 35°C and relative humidity (35%, 45%, 65%, 75% and 90%) to determine sorption characteristics. Moisture content of the cashew kernel samples are used to work out the free and bound moisture based on isotherms developed.

4.1.3 Quality assessment of cashew kernels

An attempt was made to investigate surface colour characteristics of various grades of cashew kernels obtained by steam boiling mode of processing. Ultimate aim in cashewnut processing is to extract white whole kernels which fetches premium price at consumer level. Therefore different grades of cashew kernels *viz.,* White Wholes (WW 180, WW 210, WW 240, WW 450, WW 500), Scorched Wholes (SW), Scorched Wholes Seconds (SSW), Dessert Whole (DW) and Oily Wholes (OW) were selected for present investigation. Using spectrophotometer, luminance values in terms of L, a and b were found out and change in the surface colour from standard value *i.e.* unprocessed cashew kernel were worked out as ΔE. The data recorded indicated that change in the colour value increased from 2.87 to 7.80 for the cashew kernels analyzed *i.e.* from WW180 to OW in the case of cashew kernels obtained from raw cashewnuts of Goa origin whereas values showed increasing trend from 2.86 to 11.77 for raw cashewnuts of Benin origin. Results revealed that change in the surface colour characteristics of cashew kernels depends on origin of raw cashewnuts, maturity level, storage period, mode of processing and processing parameters adopted in the line of processing. Data generated could be used for standardizing quality characteristics of cashew kernel while grading in terms of prime factor *i.e.* surface colour and for setting operational parameters of the mechanical colour sorter.

4.1.4 Performance evaluation of colour sorter for cashew kernels

In cashewnut processing industry, the quality evaluation still largely depends on manual inspection, which is tedious, laborious, and costly. Colour based classification of cashew kernel determines market price. A high speed commercial colour sorter (Fig. 4.1) was evaluated for the segregation of cashew kernels of different grades *viz.,* WW 210, WW 240, WW 450, Splits, Large White Pieces and Baby bits (BB) in terms of purity index and operational capacity.

Differences in sorting performance between large size *i.e.* WW 210 where product flow is mostly uniform and small size *i.e.* BB where product flow is partly uniform and partly non-uniform, for the same feed rate, were compared. Cashew kernels falling from a vibratory feeder is singulated and accelerated in inclined channels. Front and rear CCD cameras view each kernel once it reaches the viewing area. An air ejector is triggered to divert a kernel from its trajectory when kernel colour, as seen by either one of the cameras, exceeds a set sensitivity (or threshold) level. Diverted kernels fall into a 'reject' container, while free-falling kernels fall into an 'accept' container. Sensitivity levels can be adjusted from 1 to 999 and these numbers correspond to the per cent mass rejected. Experiments were conducted by mixing known quantity of accept and rejects in different proportions *viz.*, 100:0, 75:25, 50:50, 25:75 and 0:100 and purity index was worked out based on

the material collected in the outlets. The time taken for sorting the given quantity of the cashew sample was also observed to work out the operational capacity. It was observed that purity index for the largest size cashew kernel *i.e.* WW 210 decreased from 1.0 to 0.68 whereas purity index recorded between 1.0 and 0.41 for smallest cashew kernels *i.e.* baby bits. Number of kernels in the given mass is the due reason for the variation in the purity index for the selected size of cashew kernels. Operation capacity found to be more or less uniform for the given size of the cashew kernels but, decreased as the kernel size decreased from WW 210 to BB. Operational capacity recorded for WW 210 was found to be in the range of 152 to 156 kg/h whereas it recorded between 49 and 52 kg/h for BB for the various proportions investigated.

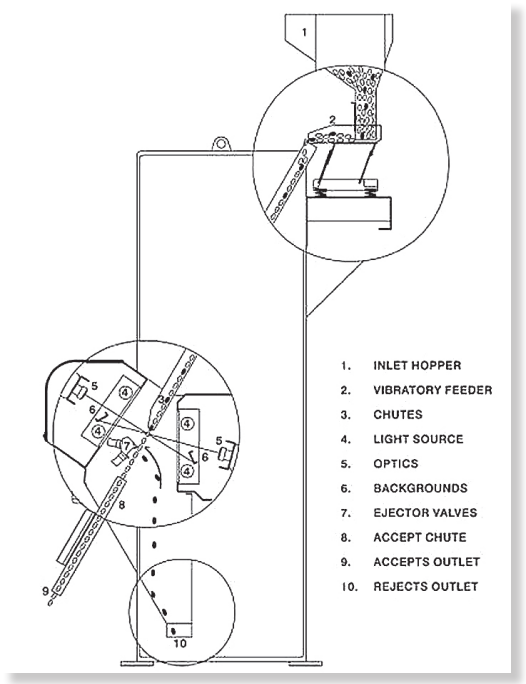


Fig. 4.1: High speed colour sorter for cashew kernels

5. TRANSFER OF TECHNOLOGY

5.1 Transfer of Technology Programme in Cashew

5.1.1 DCR-KCMA Industry Meet-2012

A DCR-KCMA Industry Meet-2012 was organized on 16 April, 2012 at Karnataka Cashew Manufacturers Association (KCMA), Mangalore to have an interaction with cashew industry and to learn their problems. The theme of the meet was 'Problems and prospects of mechanization in cashew processing'. The members representing cashew industry along with scientists of DCR participated and discussed the various issues related to mechanization of cashew processing. Mr. Prakash Kalbhavi, representing KCMA gave a talk on the requirements of the industry while Dr. D. Balasubramanian, Principal Scientist (AS&PE), DCR presented the technologies developed by DCR with respect to mechanization of processing. This was followed by industrialist - scientist interaction on future of cashew industry.

DCR-KCMA Industry Meet-2012

Scientist-industrialist interface during DCR-KCMA Industry Meet-2012

5.1.2 Innovative Cashew Farmers Meet-2012

Innovative Cashew Farmers Meet-2012 was organized at this Directorate on 18 June, 2012 to identify and document grass-root level innovations made by farmers in cashew cultivation / processing and felicitate them. Around 75 cashew farmers including innovative and progressive farmers participated in the Meet. The Meet discussed innovative approaches developed by innovative farmers such as value added products from cashew apple (cashew apple chocolate, cashew apple halwa, cashew apple suttavvu / appa and cashew apple payasa); control of tea mosquito bug using tobacco decoction; use of vermi-wash for better growth of young cashew plants; use of plastic mulch in cashew orchards for water management and innovations in improvisation of cashewnut cutting machinery. The innovations were documented from Karnataka, Maharashtra and Tripura. Sri. Ramamurthy, a progressive cashew farmer shared his experiences on method of growing black pepper as intercrop in existing cashew orchards and he indicated that cashew stem and root borer (CSRB) incidence was minimum in cashew plants having black pepper trailed on them. A farmer-scientist interaction followed where various aspects of cashew farming were discussed in detail with exchange of innovative

ideas from cashew farmers. Five innovative cashew farmers were felicitated for their contributions on this occasion. Mr. N.N. Bhat, a progessive farmer and non-

Felicitation of innovative cashew farm women

official member of IMC of DCR was the Chief Guest and he appreciated the efforts of DCR in recognizing the innovative cashew farmers.

5.1.3 Agricultural Education Day-2013

Agricultural Education Day-2013 was organized at DCR, Puttur on 30 January, 2013. Around 260 students along with their teachers from various schools and colleges around Puttur

Students participating in Agricultural Education Day

participated in the programme. The students were explained on the topics: Scope of Agricultural Education, Developments in agricultural research, National Agricultural Research and Education System etc.

Prof. P.L. Saroj, Director, DCR appraised the students on Agriculture Scenario at national and global level and also the services rendered by agricultural scientists in achieving food and nutritional security. Students were taken to various experimental plots, cashew museum and laboratories and where they discussed about research achievements and technologies developed by the Directorate.

5.1.4 Annual Cashew Day-2013

Annual Cashew Day was organized at DCR, Puttur on 23 February, 2013 in which representatives of progressive farmers, nursery men, development departments and scientists shared their experience with the farmers.

Dr. M.G. Nayak, Principal Scientist (Hort.), delivered a talk on Advances in Cashew Production Technologies. He advocated that the adoption of scientific management practices along with high yielding cashew varieties is need of the hour for realizing the quantum jump in production and

Dignitaries on dias during Cashew Day-2013

productivity of cashew. He opined that technology can bring revolution in cashewnut production in the country in near future if adopted on a large area.

Dr. P.S. Bhat, Principal Scientist (Agril. Entomology), emphasized on timely management of tea mosquito bug infestation and importance of phytosanitation measures to minimize the infestation of CSRB in cashew.

Chief Guest of the function Prof. P.K. Balakrishna, Professor (Economics) of Vivekananda College, Puttur, stressed on the need for increasing profitability in cashew farming. He highlighted the importance of intercropping, scientific management practices, formation of cashew growers association and processors groups in order to increase revenue to the farmers. Sri. Balakrishna Kolathaya, Progressive cashew farmer also shared his experiences in rejuvenation of cashew orchards for increased profitability. On this occasion, Sri. Vishnu Prasad, Manager, Federal Bank, Puttur explained about various schemes for promotion of cashew cultivation.

Dr. M.G. Bhat, Former Director, DCR shared his views on high yielding varieties and scientific cultivation of cashew. Prof. P.L. Saroj, Director, DCR, in his Presidential Address stressed the need for synergy between farmers and researchers. He exhorted the farmers to follow improved technologies to get higher profit from cashew cultivation. Farmers were taken to the cashew museum, post-harvest technology workshop and various experimental plots and explained about the latest research developments. This was followed by farmer-scientist interaction session.

Visit to DCR museum

Chief Guest addressing the farmers

Visit to experimental field

Director, DCR addressing the farmers

5.1.5 Training Programmes

5.1.5.1 Training programmes on Cashew Production Technology

Two special training programmes on Cashew Production Technology (CPT) with special emphasis on rejuvenation techniques were organized at DCR on 5 January, 2013 and 19 January, 2013 for 25 farmers and 27 farmers, respectively from Dakshina Kannada district of Karnataka. Cashew production technologies, pest management, orchard management and rejuvenation techniques were explained to

ADG (Hort. I) inaugurating CPT training programme

trainees. The training programmes were sponsored by the Department of Horticulture, Dakshina Kannada district, Karnataka.

5.1.5.2 Training programme on Softwood Grafting Technique in Cashew

A training programme on Softwood Grafting Technique in Cashew was organized during 1-2 March, 2013 in which 19 officials from Department of Horticulture, Govt. of Odisha participated. Training was provided on production and maintenance of rootstock seedlings, maintenance of scion bank, production of

Preparation of cashew grafts

scions, technique of grafting, maintenance of grafts and overall nursery management techniques.

5.1.6 Exhibitions

5.1.6.1 Krishi Yantra Mela

Directorate of Cashew Research put up stall to display machineries required for on-farm processing of cashewnut to the farmers at the Krishi Yantra Mela

DCR stall at Krishi Yantra Mela, Puttur

organized by CAMPCO at Vivekananda Engineering College, Puttur during 2-4 November, 2012.

5.1.6.2 Golden Jubilee Exhibition

The Directorate of Cashew Research participated in the Golden Jubilee Exhibition organized by Cardamom Research Centre, IISR at Appangala,

DCR stall at Golden Jubilee Exhibition, Appangala

Kodagu during 20-22 December, 2012. Various cashew production and processing technologies were exhibited in the stall.

5.1.7 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.

Visit to demonstration plot

5.1.8 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.

5.1.9 Supply of planting material

More than 1,00,000 cashew grafts of high yielding and recommended varieties produced under two different revolving fund schemes *viz.,* Mega Seed Project and DCCD Revolving Fund besides the graft production under Institute Revenue Generation programme. Cashew grafts have been supplied to the farmers and developmental agencies.

5.1.10 Visitors

Visitors were taken to various experimental plots, cashew nurseries, cashew museum and laboratories and were appraised of the achievements and technologies developed by the Directorate (Table 5.1).

Table 5.1: Exposure visit to DCR during 2012-13

Visitors category	Organization	No. of participants	Date of visit
Farmers/Officials	Dept. of Agriculture, Andaman and Nicobar Islands	29	04 October, 2012
Students	College of Horticulture, Sirsi, Karnataka	36	09 October, 2012
Students/Teachers	IRD-Uppalige cluster students	57	10 October, 2012
Farmers	DATC, Chickmagalur, Karnataka	50	12 October, 2012
Students	Dept. of Applied Zoology, Mangalore University	50	12 October, 2012
Farmers	Dept. of Agriculture, Uttara Kannada, Karnataka	40	26 December, 2012
Farmers	Dept. of Agriculture, Dakshina Kannada, Karnataka	25	05 Janauary, 2013
Students	University of Agricultural Sciences, GKVK, Bengaluru	50	10 Janauary, 2013
Farmers	Dept. of Agriculture, Dakshina Kannada, Karnataka	27	19 Janauary, 2013
Students	Various schools and colleges of Puttur, Karnataka	260	30 Janauary, 2013
Farmers/Officials	Dept. of Agriculture, Raigad District, Maharashtra	18	20 February, 2013
Farmers/Officials	Dept. of Horticulture, Sullia, Karnataka	20	20 February, 2013
Farmers	Various districts of Karnataka	140	23 February, 2013
Officials	Dept. of Horticulture, Govt. of Odisha	19	01 March, 2013

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

An interview schedule to study the impact of cashew production technologies developed by DCR on the area, production and productivity trends in cashew cultivation was constructed and utilized for data collection from farmers.

5.2.1 Impact of cashew varieties on area

The study indicated that highest area under cashew was occupied by the variety Ullal-3 (41%) followed by variety Bhaskara (27%). Varieties Ullal-1 and Vengurle-4 accounted for 8 per cent each of the remaining area, while other varieties like NRCC Sel-2 (5%), Madakkathara-2 (4%), VRI-3 (3%), Ullal-4 (3%) and Vengurle-7 (1%), had low impact on total cashew area.

5.2.2 Impact of cashew varieties on production and productivity

Analysis of variety wise impact on production showed that highest yield was obtained from variety Bhaskara (4.73 kg/tree) followed by Madakkathara-2 (4.45 kg/tree), Ullal-1 (3.90 kg/tree) and Ullal-3 (3.87 kg/tree). Productivity under normal density (8 m x 8 m) as well as high density planting (5 m x 5 m) was greater with Bhaskara (738 and 1892 kg/tree) and Madakkathara-2 (694 and 1780 kg/tree) varieties (Table 5.2).

5.2.3. Impact of cashew cultivation on farmers' income

The study indicted that cashew cultivation was profitable with a B:C ratio of 3.15. The other details on impact on farm income are furnished in Table 5.3.

Table 5.2: Impact of cashew varieties on production and productivity

Variety	% Farmers adopted	Yield (kg/tree)	Productivity (kg/ha) under normal density planting (8 m x 8 m)	Productivity (kg/ha) under high density planting (5 m x 5 m)
Bhaskara	55	4.73	737.88	1892
NRCC Sel-2	19	3.47	541.32	1388
Madakkathara-2	4	4.45	694.20	1780
Ullal-3	59	3.87	603.72	1548
Ullal-1	13	3.90	608.40	1560
VRI-3	7	3.06	477.36	1224
V-4	5	1.51	235.56	604
V-7	4	3.00	468.00	1200

Table 5.3: Impact of cashew cultivation on farmers' income

Cost of cultivation/year (₹)	9,293
Gross returns (₹)	38,598
Net returns (₹)	29,304
B:C ratio	3.15
Price of raw cashew nuts (₹/kg)	68
Net income /tree /year (₹)	169
Net income/acre under 8 m x 8 m spacing (₹)	10,140
Net income/acre under 5 m x 5 m spacing (₹)	27,040
Net income/acre under 4 m x 4 m spacing (₹)	42,250
Net income/acre under 6 m x 4 m spacing (₹)	28,054
Expenditure in agriculture/ farmer (₹)	90,891
Gross returns from agriculture (₹)	2,40,540
Net returns from agriculture (₹)	1,49,649

5.2.4 Level of adoption of cashew production technologies

Adoption status of cashew production technologies like planting and initial care, soil and water conservation techniques, application of manures and feritilizers, pruning and training, plant protection, intercropping, harvesting and post harvest technology were studied in detail. The results showed that level of adoption was highest for planting and initial care technologies (72.7%) while it was lowest in case of plant protection (20.2%). Overall adoption of cashew production technologies were found to be only 40 per cent with majority of farmers (46%) falling under medium adopter category. Details of field level adoption of cashew production technologies are presented in table 5.4.

5.2.5 Economic factors affecting adoption of cashew production technologies

Economic factors affecting adoption of cashew production technologies were studied and the results showed that factors like crops other than cashew, importance given to cashew, number of cashew trees, expenditure incurred in agriculture and income derived from cashew were the factors which significantly affected the level of adoption of cashew production technologies (Table 5.5).

Table 5.4: Field level adoption of cashew production technologies

Technology	Level of adoption (%)	Rank	% Farmers under various levels of adoption			
			Low	Medium	High	Non-adoption
Planting and initial care	72.7	1	23	52	25	-
Soil and water conservation techniques	48.2	2	11	49	32	-
Application of manures and fertilizers	30.3	5	13	13	54	20
Pruning and training	42.5	4	1.3	35	33	30.7
Plant protection	20.2	7	28	25	30	17
Intercropping	22.3	6	-	-	29	71
Harvesting and post harvest technology	42.7	3	18	43	14	-
Cashew production technology (overall)	39.8	-	27	46	27	-

Table 5.5: Economic factors affecting adoption of cashew production technologies

Variable	'r' value
Crops other than cashew	0.450**
Importance given to cashew	0.393**
Farm size	0.074
Area under cashew	-0.071
Number of cashew trees	0.536**
Cashew yield	0.155
Expenditure in agriculture	0.282*
Income from agriculture	0.176
Expenditure in cashew	0.141
Income from cashew	0.420**

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

5.2.6 Personal factors affecting adoption of cashew production technologies

Personal factors affecting adoption of cashew production technologies were experience in agriculture, experience in cashew farming, and extension participation. The other personal factors studied did not influence much the adoption levels (Table 5.6).

5.6: Personal factors affecting adoption of cashew production technologies

Variable	'r' value
Age	0.134
Education	-0.081
Occupation	-0.107
Experience in agriculture	0.380**
Experience in cashew farming	0.334**
F-EW/A contact	0.205
Extension participation	0.292*
ICT usage	0.175
Land available for cultivation	0.007
Type of land for cashew	-0.030
Type of land for other crops	0.116
Distance of plot from home	-0.202

5.2.7 Constraints faced by farmers in adoption of cashew production technologies

Poor price / price fluctuation was the biggest constraint felt by farmers (83%). This was followed by low availability of labour (71%), attack of tea mosquito bug (41%), cashew stem and root borer attack (35%) and flower drying in some varieties (20%) resulting in low yield (17%) (Table 5.7).

Table 5.7: Constraints faced by farmers in adoption

Constraint	Frequency	%
Poor price / price fluctuation	62	83
Low availability of labour	53	71
Tea mosquito bug	31	41
Cashew stem and root borer	26	35
Flower drying	15	20
Low yield	13	17
Collection of nuts / theft	10	13
Price control by processors	9	12
Lack of cashew farmers association	9	12
Monkey menace	4	5
No value for cashew apple	3	4
Poor fertility status of soils	3	4

A mail questionnaire was also prepared for studying the impact of various cashew production technologies and provided to all Centres of AICRP-Cashew for data collection and compilation. This questionnaire will aid in identifying the determinants of adoption of cashew production technologies and field level constraints in various parts of the country.

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

As per ICAR guidelines, designed initial framework and collation of datasets for the development of DCR website. Further, websites of many ICAR research institutes were referred along with certain websites of international organizations. Information on various fields *viz.,* about DCR, research achievements, facilities, reports, library *etc.,* has been compiled. The existing web site www.cashew.res.in has been revamped. New website has been designed and updated.

5. CONCLUDED PROJECT

6.1 Development of compact type drum roasting machine for raw cashewnuts

Project Leader : Dr. D. Balasubramanian
Principal Scientist (AS & PE)

Project Duration : 2008-2012

6.1.1 Objectives

- To assess qualitative and quantitative performance of existing drum roasting machine and its problems related to health hazards.
- To design and develop technically superior roasting machine for conditioning raw cashewnuts.
- To optimise processing parameters in order to obtain better kernel percentage recovery in manual / mechanical shelling.
- To evaluate developed machine and preparation of technical report.

6.1.2 Results and discussion

6.1.2.1 Current scenario of drum roasting process in India

Drum roasting process for conditioning raw cashewnuts is followed in Kerala, Tamil Nadu, Andhra Pradesh, Odisha, West Bengal and NEH regions for several years. About 64 per cent of the total processing units (3799 Nos.) existing in India follows drum roasting process. During drum roasting process, dried nuts having moisture content of ≈8 per cent d.b are fed into an inclined rotating drum which is heated initially to such an extent that the exuding oil ignites and burns, thus charring the shell. The drum maintains its temperature because of the burning cashewnut shell liquid (CNSL) oozing out of the nuts. Roasting generally takes about 10 to 15 sec. and the drum is rotated by hand during this period. The roasted nuts, which are still burning are quenched off by sprinkling water and covered with ash to absorb the oil on the surface. The shell becomes brittle and the outturn of whole kernels reported to be highest in this method of conditioning process. Smoke emanating from drum roasting process is let into air at a height of 65′ through brick constructed chimney.

Drum roasting process during operation

6.1.2.2 Roasting characteristics of raw cashewnuts

Preliminary experiments on roasting characteristics revealed that temperature surrounding the nut is maintained at 100 to 250°C, oozing of CNSL was observed followed by fumes emanating from the nut. Even after a longer period of 5 min. nuts could not be ignited to initiate roasting process. Ultimate aim in roasting is to make the nut expose to hot environment to catch fire for a limited time to make it porous to ease cracking operation to extract edible kernel in whole form.

Moreover, burning should be allowed to continue for short period as far as possible to preserve the surface colour of the edible kernel, available within the nut shell which fetch premium price in the market. Therefore, it was decided to expose the raw nut to ≥350°C at which burning starts within a short time of 5 sec. Weight loss of raw cashewnuts of different sizes *viz.,* small, medium and large during roasting process using muffle furnace exposed to varied temperature of 350 to 750°C at an interval of 100°C (Fig. 6.1).

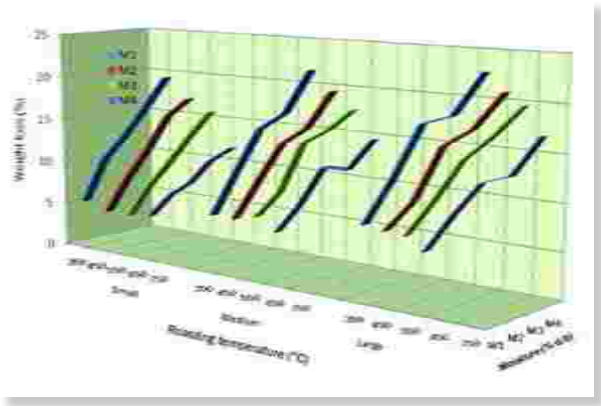


Fig.6.1: Weight loss during roasting of raw cashewnuts using muffle furnace

In general, diffusion of moisture takes place from the nuts in the beginning followed by volatile content when the surrounding temperature of the nut is raised owing to lower enthalpy of vaporization. It is evident that weight reduction was higher in large size raw cashewnuts than smaller ones. It is mainly due to total surface area of corresponding size of nuts which received heat from all directions. A total weight loss of 11.66, 14.56 and 16.79 per cent recorded for small, medium and large size nuts, respectively for the roasting temperature of 750°C.

Surface colour of peeled cashew kernels obtained after drum roasting process were assessed for browning index for the raw cashewnuts with different factors *viz.,* size, moisture content and roasting temperature. Colour value of roasted and peeled kernels in terms of L, a and b are expressed as browning index as it is the indicator of quality of final produce. Lower the value of browning index of cashew kernel, better is the quality. Factorial analysis of quality index value in terms of browning index ranged from 29.68 to 34.97 irrespective of nut size, moisture content and roasting temperature.

Statistical analysis of experimental data indicated that roasting temperature is highly significant. Optimum value for small nuts was found to be 30.05 while exposing to roasting temperature of 450°C having moisture content of 8.18 per cent d.b. In the case of medium and larger size nuts, minimum value for browning index were shown as 29.68 and 31.56 for the corresponding moisture content of 9.84 and 12.18 per cent d.b and roasting temperature of 550°C and 750°C respectively.

6.1.2.3 Performance evaluation of drum roasting machine

Quantity of whole kernel recovered during drum roasting process has strong bearing on the economics of processing raw cashewnuts. Therefore, whole kernel recovery was worked out after drum roasting of raw cashewnuts for different experiments conducted wherein size of the nuts, moisture content of nuts, feed rate and rpm of the drum roaster were varied. Factorial analysis of data revealed that size and initial moisture content of the nuts found to be significant.

As the thermal conductivity depends on the thickness of the shell and initial moisture content, larger nuts showed better results at lower drum speed (13 rpm) and higher moisture level of the nut *i.e.* 15.4 per cent d.b. In the case of smaller size nuts, whole kernel recovery recorded a higher value of 84.5 per cent for a feed rate of 698 kg/h at drum speed of 19 rpm having initial moisture content of 8.9 per cent d.b.

Optimum value of whole kernel recovery *i.e.* 83 per cent was obtained for medium size nuts possessing moisture content of 12.7 per cent d.b while the drum rotation was around 13 rpm. It clearly indicates that at a constant roasting drum temperature of >320°C which is expectedly reached ≈600°C at the time of burning nuts, different size of nuts need to be subjected to varying feed rate, moisture content and drum speed towards maximizing whole kernel recovery. Therefore, it is recommended to process graded nuts by drum roasting machine in order to achieve the ultimate aim of recovering high whole kernels after shelling or cracking operation.

Whole kernels having white surface colour after peeling is considered as superior quality. Cashew kernels obtained after drum roasting process subjected to varying material and machine parameters were peeled manually and its surface colour was assessed in terms of L, a and b. Based on the colour values, brightness index was worked out. Small size nuts having initial moisture content of 8.8 per cent d.b. showed higher brightness at lower drum speed of 13 rpm. But in case of medium and larger size nuts, better brightness values were recorded while operating the drum at a speed of 19 rpm with the moisture content of 12.3 per cent d.b. and 15.4 per cent d.b. respectively. As the factorial analysis clearly indicated that feed rate is non-significant, drum roasting machine could be operated with an operational capacity of 600-650 kg/h irrespective of size of the nuts.

Peak force and energy required for cracking nuts which were subjected to varying material and machine parameters during roasting process were found out in different orientations of the nuts *viz.*, concave, convex (both perpendicular to major axis), apex and stem (both parallel to major axis). Significant difference in the peak force required for cracking the shelves of the nuts is recorded irrespective of size, moisture, rotational speed and feed rate experimented. Minimum peak force exerted by the drum roasted cashewnuts in different orientations found to be 13.5, 12.8 and 11.4 kg for small, medium and large size nuts respectively and the corresponding maximum peak force were 63.0, 55.7 and 54.9 kg. In many cases, either concave or convex sides of the roasted nut offered maximum resistance for developing the crack than the stem or apex end. It is primarily due to larger surface area against quasi-static load applied in the concave or convex side than other two sides investigated. Although higher force required for cracking the nut in the concave or convex side, due to longer line joining the two shelves of the nuts, which ensured splitting of the nut to extract of the edible kernel in whole form, these two sides are preferred.

Interactive effect of all the machine and material parameters indicated significantly different for the total cracking energy required to develop crack using compressive load applied in various orientations investigated. Energy required to develop the crack was in the range of 13.5 to 63.0 kg-m, 12.8 to 55.7 kg-m and 11.4 to 54.9 kg-m for small, medium and larger size nuts, respectively. In majority cases, convex side required maximum energy irrespective of size of the roasted nuts and stem end required minimum energy. Degree of brittleness (porous texture) developed during roasting process and total surface area after roasting could be the two major factors highly contributed for the differential energy requirement. Roasting period within the drum influenced the development of porous condition of the nuts and roasting temperature being constant, high moisture content, less rotational speed of the drum and high feed rate are the major causes for the change in the textural profile of the nut. Energy requirement for the roasted cashewnuts will be quite useful for the development of cracking or shelling tool for the nuts.

6.1.3 Conclusions

- A total of 64 per cent of the cashewnut processing units located in east and west coast follows drum roasting process. Skilled labourers are required to operate the existing drum roasting machine and their coordination plays an important role in obtaining good quality end product.
- Feed rate, temperature of furnace *i.e.* resident time of nuts being roasted while passing along the slope of revolving drum and rpm of drum are the deciding factors to extract white whole kernels after shelling. However, these processing parameters are yet to be optimized for better white whole kernel recovery.
- Present system requires large space for installation of drum roasting machine involving high fixed capital. Growing problem of labour scarcity in the processing region necessitates the demand for mechanized and compact type drum roasting machine.
- Roasting characteristics of raw cashewnuts were evaluated using muffle furnace considering variable parameters *viz.,* size of the nut, initial moisture content and roasting temperature and its final quality was assessed in terms of weight loss, whole kernel recovery, surface colour characteristics of cashew kernel and textural profile analysis.
- Higher the roasting temperature, rate of diffusion of moisture and volatiles from the nut were found to be higher, but charred the nuts. A weight loss of 11.66, 14.56 and 16.79 per cent recorded for small, medium and large size nuts respectively for the roasting temperature of 750°C.
- Quality index value in terms of browning index ranged from 29.68 to 34.97 irrespective of nut size, moisture content and roasting temperature. Optimum value for small nuts was found to be 30.05 while exposing to roasting temperature of 450°C having moisture content of 8.18 per cent d.b.
- A compact type mechanized drum roasting machine was developed and processing parameters were optimized for better kernel quality for various sized nuts. Drum roasting machine consists of material conveyor, drum roaster, gas burner and power transmission mechanism operated by electric motor (0.74 kW).
- During roasting process, thermal conductivity depends on the thickness of the shell and initial moisture, larger nuts showed better results at lower drum speed (13 rpm) and higher moisture level of the nut (15.4 % d.b).
- Optimum value of whole kernel recovery *i.e.* 83 per cent was obtained for medium size nuts possessing moisture content of 12.7 per cent d.b while the drum rotation was around 13 rpm.
- It is recommended to process graded nuts by drum roasting machine in order to achieve the ultimate aim of recovering high whole kernels after shelling or cracking operation.
- Minimum peak force exerted by the drum roasted cashewnuts in different orientations found to be 13.5, 12.8 and 11.4 kg for small, medium and large size nuts, respectively and the corresponding maximum peak force were 63.0, 55.7 and 54.9 kg. In many cases, either concave or convex sides of the roasted nut offered maximum resistance for developing the crack than the stem or apex end.
- Energy required to develop the crack was found to be in the range of 13.5 to 63.0 kg-m, 12.8 to 55.7 kg-m and 11.4 to 54.9 kg-m for small, medium and larger size nuts, respectively. Degree of brittleness (porous texture) developed during roasting process and total surface area after roasting could be the two major factors highly contributed for the differential energy requirement.

ADDITIONAL INFORMATION

7. LINKAGES / COLLABORATION

Organization	Area of collaboration
National Bureau of Agriculturally Important Insects (NBAII), Bengaluru	Identification of kairomones/ pheromones of major pests of cashew.
Indian Institute of Horticultural Research (IIHR), Bengaluru	Biosystematics of tea mosquito bug and natural enemies of tea mosquito bug.
University of Agricultural Sciences (UAS), GKVK, Bengaluru	Identification of arthropod fauna associated with cashew.
Indian Agricultural Research Institute (IARI), New Delhi	Identification of arthropod fauna associated with cashew.
Central Institute for Agricultural Engineering (CIAE), Bhopal	Development of improved cashew processing machinery.
SKDRDP, Dharmasthala Manaje Vyavasaya Sahakari Seva Society, Kamalashile Nagarika Seva Trust, Guruvayanakere	Maintenance of demonstration plots, trainings, distribution of planting materials and Annual Cashew Day.
Directorate of Cashewnut and Cocoa Development (DCCD), Kochi	Farmers training programme, Annual Cashew Day and front line demonstration plots.
Cashew Export Promotion Council of India (CEPCI), Kollam	NAIP Project on 'A value chain in cashew for domestic and export market'.
Department of Horticulture, Karnataka Horticultural Research Station, Ullal, Mangalore.	Farmers training programmes, Krishi Mela.
Zonal Agricultural Research Station, Brahmavar, Udupi district, Karnataka	Farmers training programmes, Krishi Mela.
KVK, Mangalore	Transfer of technology.
AICRP-Cashew Centres	Multilocational testing, exchange of research findings / germplasm / planting material.

8. PUBLICATIONS

8.1 Research publications

8.1.1 International

Rebijith, K.B., Asokan R., Krishna Kumar, N.K., Srikumar, K.K., Ramamurthy, V.V. and Bhat, P.S. 2012. DNA barcoding and development of species-specific markers for the identification of Tea Mosquito Bugs (Miridae: Heteroptera) in India. *Environmental Entomology,* 41(5):1239-1245.

Srikumar, K.K. and Bhat, P.S. 2012. Field survey and comparative biology of tea mosquito bug (*Helopeltis spp.*) on cashew (*Anacardium occidentale* L.). *Journal of Cell and Animal Biology,* 6(14): 200-207.

Kumar, N., Ponnuswami, V., Jeeva, S., Ravindran, C. and Kalaivanan, D. 2012. Cashew Industry in India - An Overview. *Chronica Horticulturae,* 52 (1): 23-29.

Vasanthi, P. and Raviprasad, T.N. 2013. Biology and morphometrics of cashew stem and root borers (CSRB) *Plocaederus ferrugineus and Plocaederus obesus* (Coleoptera: Cerambycidae) reared on cashew bark. *International Journal of Scientific and Research Publ.,* 3 (1): (on line) ISSN 2250-3153.

8.1.2 National

Balasubramanian, D. and Joycy, R.L.K. 2012. Cashewnut Processing in West Bengal - Current Status and Challenges, *The Journal of Cashew and Cocoa,* 42(2): 14-22.

Bhat, P.S. and Srikumar, K.K. 2012. Record of *Erythmelus helopeltidis* Gahan (*Hymenoptera: Mymaridae*), an egg parasitoid from *Pachypeltis maesarum* (Heteroptera: Miridae) infesting cashew. *Pest Management in Horticultural Ecosystem,* 18(1): 103-104.

Rejani, R., Adiga, J.D. and Yadukumar, N. 2013. Performance of different varieties of cashew under high density planting system. *Journal of Plantation Crops,* 41(1): 28-33.

Rejani, R. and Yadukumar, N. 2012. A nutrient decision support system for rainfed cashew. *Journal of Plantation Crops,* 40 (1): 40-49.

Srikumar, K.K. and Bhat, P.S. 2013. Biology and feeding behaviour of *Helopeltis antonii* (Hemiptera: Miridae) on Singapore cherry (*Muntingia calabura*) - a refuge host. *Journal of Entomological Research,* 37(1): 11-16.

Vasanthi, P. and Raviprasad, T.N. 2012. Relative susceptibility of cashew stem and root borers, *Plocaederus spp. and Batocera rufomaculata De.Geer.* to entomopathogenic fungi. *J. Biol. Control,* 26(1): 23 -28.

Yadukumar, N., Rejani, R. and Nandan, S.L. 2012. Studies on organic and inorganic manuring in cashew. *Journal of Plantation Crops,* 40 (1):1-8.

Yadukumar, N., Rejani, R., Nandan, S.L. and Prabhakar, B. 2013. Nutrient budgeting and nutrient balance studies under high density planting system in cashew. *Indian Journal of Agricultural Sciences,* 83(1): 14-21.

8.2 Papers presented in symposia /workshops / seminars

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8.3 Book chapters

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8.4 Technical reports / compendia / articles

Annual Report 2011-12. Directorate of Cashew Research, Puttur, pp. 104 (Eds: P.S. Bhat and T.R. Rupa).

Annual Report 2011-12. All India Co-ordinated Research Project on Cashew, Directorate of Cashew Research, Puttur, pp.130 (Eds: T.N. Raviprasad and P.L. Saroj).

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Cashew Newsletter 2012. Directorate of Cashew Research, Puttur, Vol. 17(1), pp.12 (Eds: T.R. Rupa and J.D. Adiga).

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Summary Proceedings and Recommendations- Silver Jubilee Celebrations (1986-2011) of Directorate of Cashew Research, Puttur 2012, pp. 30. (Eds: T.R. Rupa, M.G. Bhat, M.G. Nayak, T.N. Raviprasad and R. Rejani).

DCR Directory 2013. Directorate of Cashew Research, Puttur, pp. 42 (Eds: G.S. Mohana, D. Balasubramanian, M.V. Sajeev, T.N. Raviprasad and R. Muthuraju).

8.5 Extension bulletins / pamphlets

Raviprasad, T.N. 2012. Kaju ki unnathsheel prajaathiya (in Hindi) [Improved varieties of cashew], DCR Technical Pamphlet, pp.16.

Nayak, M.G., Bhat, P.S., Dinakara Adiga, J.D. and Sajeev, M.V. 2013. Improved cultivation practices in cashew (Sudhaarita Geru Besaaya) (Kannada), Directorate of Cashew Research Extension Handout No.1, pp. 6 (Revised).

8.6 Technical bulletin

Balasubramanian, D. 2013. Development of concentric drum type rotary sieve grader for raw cashewnuts. Directorate of Cashew Research, Technical Bulletin No. 23, pp.20.

8.7 Technical / Popular articles

Balasubramanian, D. 2012. Development of concentric drum type rotary grader for raw cashewnuts. Cashew News, January - June, 2012. 17(1) : 2-4.

Bhat, M.G. and Rupa, T.R. 2012. Current trends in cashew research in India and future focus. Souvenir, PLACROSYM XX, 12-15 December, UPASI, Valparai, Coimbatore, Tamil Nadu, pp.19-27.

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8.8 Scientific/ teaching review

Saroj, P.L. and Balasubramanian, D. 2013. Cashew Industry in India-a sustainable road map. Indian Horticulture, 58(1) : 9-15.

9. RESEARCH PROGRAMMES

9.1 List of ongoing research projects

Project No.	Title
1. CROP IMPROVEMENT	
1.1	Collection, conservation, evaluation and documentation of cashew germplasm (M.G. Nayak, P.S. Bhat, G.S. Mohana, E. Eradasappa and Ramkesh Meena).
1.2	Genetic improvement of cashew for yield and quality traits (J.D. Adiga, G.S. Mohana, M.G. Nayak and Ramkesh Meena).
1.2.1	Development of dwarf and compact cashew hybrids suitable for high density planting (E. Eradasappa, G.S. Mohana, J.D. Adiga and M.G. Nayak).
1.8	Application of molecular markers in cashew (Thimmappaiah and J.D. Adiga).
1.8.1	Genetic analysis of mapping population through molecular markers for important traits in cashew (G.S. Mohana, Thimmappaiah, J.D. Adiga and E. Eradasappa).
2. CROP MANAGEMENT	
2.11	Performance of high yielding varieties of cashew in different high density planting system (J.D. Adiga, Ramkesh Meena and D. Kalaivanan).
2.15	Rootstock studies in cashew (J.D. Adiga, M.G. Nayak and D. Kalaivanan).
2.16	Effect of foliar application of nutrients on growth, fruit set, yield and quality of cashew (T.R. Rupa).
2.17	Maximization of yield in irrigated cashew and sustaining soil productivity through integrated nutrient management (T.R. Rupa and D. Kalaivanan).
2.18	Effect of Paclobutrazol on growth and yield of cashew (Ramkesh Meena, M.G. Nayak and J.D. Adiga).
2.19	Irrigation requirement for cashew under high density planting system (D. Kalaivanan, J.D. Adiga and T.R. Rupa).
2.20	Organic farming in cashew (D. Kalaivanan, T.R. Rupa and P.S. Bhat).
3. CROP PROTECTION	
3.15	Evaluation of alternate techniques for the management of cashew stem and root borer (T.N. Raviprasad and P.S. Bhat).
3.16	Studies on causes of black spot formation on cashew kernels (T.N. Raviprasad).
3.17	Biodiversity of arthropod fauna in cashew eco-system (P.S. Bhat, T.N. Raviprasad and K. Vanitha).

3.18	Evaluation of certain repellents against storage insect pest (*Ephestia cautella* - Pyralidae : Lepidoptera) infesting stored cashew kernels (T.N. Raviprasad and P.S. Bhat).
3.19	Evaluation of indigenously occurring natural enemies for their efficacy in managing cashew stem and root borers (CSRB) and tea mosquito bug (TMB) (T.N. Raviprasad, K. Vanitha and P.S. Bhat).
Network	ORP on management of sucking pests in horticultural crops (P.S. Bhat and T.N. Raviprasad).
4 . POST HARVEST TECHNOLOGY	
4.12	Studies on alternate energy utilization of cashewnut shell cake (D. Balasubramanian).
4.14	Development of compact type drum roasting machine for raw cashewnuts (D. Balasubramanian and S.D. Deshpande).
4.15	Utilization of solar energy for drying cashewnut and apple (D. Balasubramanian).
NAIP	A value chain on cashew for domestic and export market (Consortium partner: D. Balasubramanian).
5. TRANSFER OF TECHNOLOGY	
5.1	Transfer of technology programmes in cashew (Sajeev, M.V., M.G. Nayak, P.S. Bhat, J.D. Adiga and T.R. Rupa).
5.2	Impact of cashew production technologies on area, production and productivity of cashew (Sajeev, M.V.).
5.3	Development of an interactive and dynamic web-space for cashew information management at DCR (G.S. Mohana and M.V. Sajeev).

9.2 ICAR consortia / Network partner

- Production of quality seeds and planting materials in horticultural crops.
- Micronutrient management in horticultural crops.
- Organic farming in horticultural crops.
- Management of borers in horticultural crops.
- ORP on Management of sucking pests in horticultural crops.

9.3 External funded projects

- DBT: Evaluation of indigenous strain of fungal pathogen *Beauveria bassiana* against *Helopeltis* spp.
- NAIP: A value chain in cashew for domestic and export market.

10.0 राजभाषा कार्यान्वयन एवं प्रगति

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

वर्ष 2012-13 में राजभाषा कार्यान्वयन समिति की बैठकें नियमित रूप से आयोजित हुई। हर बैठक में निदेशालय में हो रही हिन्दी कार्यान्वयन के संबंध में चर्चा की गयी । केंन्द्र से आए पत्रों एवं सूचना के बारे में भी चर्चा की गयी। वार्षिक कार्यक्रम में दी गयी लक्ष्य प्राप्ति के लिए कदम उठाने के बारे में चर्चा की गयी एवं अनेक निर्णय भी लिए गए ।

हिन्दी में कार्यालयीन कर्मचारियों को प्रोत्साहन देने के लिए पुरस्कार योजना जारी है। प्रशासन अनुभाग में हिन्दी में काम करने वालों में उत्साह बड़ा है। निदेशालय के बहुसंख्यक कर्मचारी हिन्दी में कार्य साधक ज्ञान प्राप्त कर चुके हैं। कर्मचारियों को प्रशिक्षण दिलाने की कोशिश जारी है। निदेशालय के ग्रंथालय मे अनेक उपयुक्त हिन्दी पुस्तकों को खरीदा गया था ।

कार्यालय में सभी नामफलक, प्रपत्र, मोहरे आदियों को द्विभाषी में बनवाया गया है। कर्मचारियों में हिन्दी में काम करने की झिझक दूर करने के लिए समय समय पर हिन्दी कार्यशालाओं का आयोजन किया जा रहा है। सितंबर में आयोजित हिन्दी पखवाडा में हमेशा की तरह कर्मचरियो ने बडे उत्साह से भाग लिये हैं। इसी अवसर पर डॉ. टी. एन. रविप्रसाद द्वारा तैयार किया गया, एक हिन्दी प्रकाशन का विमोचन किया गया।

पुत्तूर नगर राजभाषा कार्यान्वयन समिति (नराकास)

काजू अनुसंधान निदेशालय, पुत्तूर नगर राजभाषा कार्यान्वयन समिति (नराकास) का संयोजक कार्यालय है। यह पुत्तूर नराकास की 23 सदस्य कार्यलायों की राजभाषा गतिविधियों की समीक्षा करता है । उनको बढ़ावा देने के लिए जरूरी कार्यक्रमों आयोजन करता है।

इस वर्ष जून और जनवरी में, पुत्तूर नराकास की दो अर्धवार्षिक बैठकें आयोजित हुई। इन बैठको में पुत्तूर और विट्टल के सभी केन्द्र सरकारी कार्यालय प्रधान / अधिकारियो ने भाग लिया। हर सदस्य कार्यालय में हो रही गतिविधियों की समीक्षा करना और उन्हें आगे बढ़ाने के लिए जरूरी सूचना, मार्गदर्शन देना इन बैठकों का उद्देश्य था । इसी दृष्टी से अनेक विचारों पर चर्चा की गयी और निर्णय भी लिए गए। जून में आयोजित अर्धवार्षिक बैठक के अवसर पर डॉ एम. जी. भट्, निदेशक एवं अध्यक्ष पुत्तूर नराकास, की सेवा निवृत्ती पर भावपूर्ण विदाई दी गई।

सभी सदस्य संघटनों के कर्मचारियों की सुविधा के लिए जनवरी महिने में एक दिवसीय हिन्दी कार्यशाला आयोजन किया गया था। अनेक विद्धानों ने कार्यशाला में कर्मचारियों को मार्गदर्शन किया।

सितंबर 14-28 तक बहुत उत्साहपूर्ण वातावरण में हिन्दी पखवाड़ा मनाया गया। इस अवसर पर कर्मचारियों और

विद्यार्थियों के लिए अनेक प्रतियोगिताओं का आयोजन किया गया। विद्यार्थियों को, हिन्दी सीखने की प्रेरणा देने के लिए हिन्दी परीक्षाओं में उत्तम अंक पाने वाले को नगद पुरस्कार से सम्मानित किया गया। हिन्दी की प्रसारण को विस्तृत रूप देने की दृष्टी से हिन्दी अध्यापकों और विद्यार्थियो के माता पिता को भी कार्यक्रम में शामिल किया गया।

11. PARTICIPATION IN SYMPOSIA / CONFERENCES / SEMINARS / MEETINGS

Mohana, G.S.	National Workshop on Nuclear Technology for Human Welfare at Mangalore University, Mangalore, Karnataka.	28 April, 2012
Eradasappa, E.	Plant Breeders Meet at NBPGR, New Delhi.	3-4 May, 2012
Nayak, M.G.	Horticultural Division Meeting at ICAR, New Delhi.	23 June, 2012
Mohana, G.S.	Joint Meeting to finalize the publication of package of practices of Horticultural crops at IIHR, Bengaluru.	25-26 June, 2012
Nayak, M.G.	Knowledge Meet - organized by ICAR, New Delhi at NASC Complex, New Delhi.	21-22 July, 2012
Mohana, G.S.	The 2nd Asia Regional Conference of the Society for Conservation Biology, Bengaluru.	7-10 August, 2012
Nayak, M.G. Bhat, P.S.	Backward district Development Programme chaired by Secretary DARE &DG, ICAR held at Karwar, North Kanara district.	1 September, 2012
Saroj, P.L.	Selection Committee Meeting at ASRB, Pusa, New Delhi as representative of the DG, ICAR for the discipline of Agricultural Structure & Process Engineering.	5 September, 2012
Nayak, M.G.	Advisory meeting of KVK at ZARS, Brahmavar, Karnataka.	5 September, 2012
Saroj, P.L	Selection Committee Meeting at ASRB, Pusa, New Delhi as representative of the DG, ICAR in the discipline of Agricultural Entomology.	11 October, 2012
Nayak, M.G. Bhat, P.S. Balasubramanian, D.	International Conference on Cashew organized by Directorate of Cashewnut and Cocoa Development, Kochi at Panjim, Goa.	11-12 October, 2012
Nayak, M.G.	National Workshop on Indigenous Traditional Knowledge held at NIRD, Rajendranagar, Hyderabad.	29-30 October, 2012
Saroj, P.L.	5th Horticulture Science Congress-2012 at Pal Auditorium, Punjab Agriculture University, Ludhiana and received the Fellowship of the Horticultural Society of India.	6-9 November, 2012
Mohana, G.S. Kalaivanan, D.	5th Horticulture Science Congress-2012 at Pal Auditorium, Punjab Agriculture University, Ludhiana.	6-9 November, 2012
Nayak, M.G.	Inspection and evaluation of KCDC plantations raised in Uttara Kannada and Udupi districts of Karnataka under financial support of National Horticulture Mission.	15-17 November, 2012
Saroj, P.L.	Organized and participated in the Annual Group Meeting of Scientists of AICRP Cashew (AGM-2012) at Navsari Agricultural University, Navsari, Gujarat.	19-22 November, 2012

Nayak, M.G. Rupa,T.R. Raviprasad, T.N. Ramkesh Meena Prakash G. Bhat	National Group Meeting of Research Scientists of AICRP on Cashew at Navsari Agricultural University (NAU), Navsari, Gujarat.	20-22 November, 2012
Saroj, P.L.	Meeting of Project Coordinators of AICRPs convened by Secretary, DARE & DG, ICAR at NBPGR, New Delhi and participated in the discussion about streamlining and consolidating the AICRPs and budget details of XI Plan and budgetary outlay for XII Plan.	5-6 December, 2012
Bhat, P.S.	Sensitization meeting of Scientist – in-charge of all PME cells of ICAR under the Chairmanship of DG, ICAR at National Dairy Research Institute, Karnal.	8 December, 2012
Balasubramanian, D. Joycy, R.L.K.	Plantation Crops Symposium (PLACROSYM XX) conducted by UPASI, Valparai, Tamil Nadu at Jenny's residency, Coimbatore, Tamil Nadu.	12-15 December, 2012
Nayak, M.G.	National consultation on PGR management in Horticulture held at NBPGR, New Delhi.	18-19 December, 2012
Saroj, P.L.	Discussion held under the Chairmanship of DG, ICAR at Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli regarding establishment of Centre of Excellence in Mango and Cashew at Vengurle.	23 January, 2013
Saroj, P.L. Bhat, P.S.	Meeting convened by DDG (Horticulture), related to EFC proposals for XII Plan in respect of DCR and AICRP Cashew at NASC, New Delhi.	12 February, 2013
Saroj, P.L. Bhat, P.S.	Meeting of HOD and Directors of the Institutes under the chairmanship of DG, ICAR at NASC, New Delhi.	13 February, 2013
Nayak, M.G. Mohana, G.S.	National Consultative Workshop and Training Programme on Tree Varietal Registration : Challenges and Opportunities jointly organized by PPV & FRA and Forestry College of Forestry (UAS, Dharwad), at Sirsi, Karnataka.	16-17 February, 2013
Balasubramanian, D.	MDP Workshop on Technology Management for Researchers conducted jointly by National Academy of Agricultural Research Management (NAARM), Hyderabad and Zonal Technology Management Unit, Central Institute of Fisheries Technology, Cochin, Kerala at NAARM, Hyderabad.	28 February - 6 March, 2013
Eradasappa, E.	National Workshop on Foresight and Future Pathways of Agricultural Research Through Youth In India at NASC, New Delhi.	1-2 March ,2013
Balasubramanian, D.	Annual Meeting of ZTMU-BPD, convened by Central Institute of Fisheries and Technology, Cochin, Kerala at Directorate of Oil Seed Research, Hyderabad, Andhra Pradesh.	7 March, 2013

Dr. Mohana, G.S.	Capacity Building workshop on Agropedia and Open Access Institutional Repository at ICRISAT, Patancheru, Andhra Pradesh. 11-12 March, 2013	Raviprasad, T.N.
Adiga, J.D.	National Level Training Programme on Cashew Production and Processing organized by Zonal Agricultural Research Station, (University of Horticultural Sciences, Brahmavara, Udupi district, Karnataka.	13 March, 2013
Saroj, P.L.	ICAR Directors' Conference held at NASC Complex, Pusa, New Delhi.	19-20 March, 2013
Nayak, M.G.	National Consultation Meeting on High Density Planting and Canopy Management in Horticultural crops organized by HC & RI, Coimbatore, TNAU at Coimbotore, Tamil Nadu.	25 March, 2013
Mohana, G.S.	Training cum awareness program about the provisions of the Protection of Plant Varieties and Farmers Rights Act, Central Plantation Crops Research Institute, Regional Station, Vittal, Karnataka.	26 March, 2013

12. FARMER'S DAY / KRISHI MELA / CAMPAIGNS / CONSULTANCY

Nayak, M.G.	Cashew Day organized at Zonal Agricultural Research Station, Brahmavar, Udupi district, Karnataka.	21 April, 2012
Nayak, M.G.	Cashew Seminar organized by DCCD and NGO at Soraba, Shimoga, Karnataka.	22 April, 2012
Director, all scientists and technical staff	Innovative Cashew Farmers Meet, DCR, Puttur, Karnataka.	16 June, 2012
Balasubramanian, D. Sajeev, M.V.	Krishi Yanthra Mela at Vivekananda Engineering College, Puttur, Karnataka organised by CAMPCO, Puttur, Karnataka.	2-4 November, 2012
Bhat, P.S.	Krishi Mela organized at Zonal Agricultural Research Station, Brahmavar, Udupi district, Karnataka.	8 October, 2012
Sajeev, M.V.	Golden Jubilee Exhibition and Farmers day at Cardamom Research Centre, Appangala, Karnataka.	20-22 December, 2012
Director, all scientists and technical staff	Cashew Day at Directorate of Cashew Research, Puttur, Karnataka.	23 February, 2013
Nayak, M.G., Sajeev, M.V., Vanitha, K.	Cashew Mela at Horticultural Research Station, Ullal, Mangalore.	13 March, 2013
Nayak, M.G.	Horticultural Fair organized by DCCD, Kochi and Academy for Sustainable Development at Shimoga, Karnataka under NHM programme.	16 March, 2013

13. HUMAN RESOURCE DEVELOPMENT

Executive Development Programme		
Saroj, P.L.	Executive development programme on Leadership Development organized for the benefit of newly recruited Directors and other RMPs of ICAR at NAARM, Hyderabad.	17-21 December, 2012
Capacity Building Programmes		
Balasubramanian, D.	Training on Operation of gasifier conducted by Central Institute for Agricultural Engineering (CIAE), Bhopal, Madhya Pradesh.	30 April-4 May, 2012
Rupa ,T.R. Balasubramanian, D.	Consultancy Project Management conducted by National Academy of Agriculture Research Management (NAARM), Hyderabad.	7-14 August, 2012
Kalaivanan, D.	DST-NRDMS Sponsored Summer Training Programme on Geospatial Technologies and Applications organized by Department of Remote Sensing and Geographic Information System, TNAU, Coimbatore.	22 August - 11 September, 2012
Nayak, M.G.	Advanced Technology Management Programme organized by ASCI, Hyderabad.	18 September - 22 October, 2012
Sajeev M.V.	Information and Communication Technologies for Agricultural Knowledge Management at NAARM, Rajendra Nagar, Hyderabad.	3-17 October, 2012
Eradasappa, E.	CAFT training on Quantitative Genetics in the Era of Genomics at CPBG, TNAU Coimbatore.	16 November - 6 December, 2012
Sajeev M.V.	Non-parametric Approaches in Crop Modelling at CPCRI, Kasaragod.	20-29 November, 2012

14. RADIO TALK / INTERVIEW / TV PROGRAMMES

i) Radio talk / Interview

Nayak, M.G.	Cashew varieties and rejuvenation in cashew at All India Radio, (AIR), Mangalore.	4 May, 2012
Bhat, P.S.	Integrated pest Management in cashew plantations - at AIR, Mangalore.	22 May, 2012
Raviprasad, T.N.	Plant protection after care in young cashew grafts - at AIR, Mangalore.	12 July, 2012
Adiga, J.D.	Rejuvenation of senile cashew orchards - at AIR, Mangalore.	31 August, 2012

ii) TV Programmes

Nayak, M.G.	Recorded a TV talk on Pruning and canopy management in cashew - by Kannada Channel of Doordarshan, Bangalore.	22 June, 2012

15. SERVICES OFFERED TO FARMERS

Sale of cashew grafts: DCR has a cashew nursery accredited by National Horticulture Board (NHB) to cater the need of planting materials. Soft wood grafts of varieties like Bhaskara, Ullal-3, Ullal-1, VRI-3, Vengurle-7, Vengurle-4, Dhana etc. are available for sale in the nursery from 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 and K, and Exch. Ca., Exch. Mg, micronutrients such as Fe, Mn, Cu and Zn.

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

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

16. AWARDS / RECOGNITIONS

i) **Accreditation of DCR nurseries :** Accreditation for the nurseries of Directorate of Cashew Research (DCR), Puttur:- DCR, Puttur, is known for the supply of quality planting material in cashew. Ever since the standardization of soft wood grafting (wedge-cleft method) by DCR, the Directorate has been regularly supplying the quality grafts of popular varieties like Bhaskara, NRCC Sel-2, Ullal-1, Ullal-3, Vengurle-4, Vengurle-7, Priyanka, Dhana, Madakkathara-2, VRI-3 etc. to the end users. About two lakh grafts are annually produced from the nurseries located at Kemminje campus and Experimental Station, Shantigodu. Based on the evaluation made by Expert Committee of National Horticulture Board, Gurgaon, on 16 May, 2012, accreditation was issued to the nurseries of DCR with a rating of 4 star (Excellent). Out of the 3 nurseries in the country that were rated as Excellent (****), two nurseries are from DCR (Kemminje and Shantigodu campus). The rating was done based on production system, operation procedure, trading practices, record keeping, etc.

ii) Prof. P.L. Saroj, Director - Conferred with Fellowship of the Horticultural Society of India for the year 2012, for his outstanding contribution in Horticulture.

iii) Prof. P.L. Saroj, Director - Chief Guest for inaugurating Model Training Course on 'Value Addition through Product Diversification in Coconut' held at CPCRI, Kasaragod on 16 November, 2012.

iv) Prof. P.L. Saroj, Director - Guest of Honour during Seminar on 'Challenges and Prospects of Arecanut and Cocoa under changing Climatic Scenario' on 25 September, 2012 at CPCRI (RS), Vittal, Karnataka.

v) Prof. P.L. Saroj, Director - Guest of Honour during Seminar on Training-cum-awareness programme sponsored by the Protection of Plant Varieties and Farmers' Right Authority on 26 March, 2013 at CPCRI (RS), Vittal, Karnataka.

17. IMPORTANT MEETINGS

17.1 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, 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 Member
Prof. M. Udayakumar, Emeritus Scientist, Department of Crop Physiology, University of Agricultural Sciences, GKVK, Bengaluru - 560 065, Karnataka.	Member
Dr. M. Gopalakrishna Bhat, Director, Directorate of Cashew Research, Puttur - 574 202, Dakshina Kannada district, Karnataka.	Member
Prof. P.L. Saroj, 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
Shri N. Narayana Bhat, Rtd. Bank Manager, Noojibail House, Manchi Post, Bantwal Tq., Dakshina Kannada district, Karnataka - 574 323.	Member
Dr. T.N. Raviprasad, Principal Scientist, Directorate of Cashew Research, Puttur - 574 202, Karnataka.	Secretary

The first meeting of the sixth Research Advisory Committee (RAC) (16th meeting) of the Directorate was held during 21-22 May, 2012 under the chairmanship of Dr. P. Rethinam. Dr. M.G. Bhat, Director, briefed the RAC about the present scenario and prospects of cashew production in India and gave an overview of research activities on cashew being done at this Directorate. Later, in his opening remarks opined that research work should cater to the needs of the farmer. He pointed out that the North Eastern Hilly regions have good potential for cashew area expansion and nurseries need to be established locally there to avoid transportation cost of cashew grafts. Dr. K.U.K. Nampoothiri, Dr. K.V. Ramana, Dr. S. Chandrasekharan, Dr. M. Udayakumar, Dr. P.M. Haldankar, and Shri. N. Narayana Bhat participated in the meeting and the progresses made under the research projects were discussed and recommendations were made.

17.2 Institute Management Committee

Name and Address	Status
Dr. M.G. Bhat, Director, DCR, Puttur - 574 202, Dakshina Kannada district, Karnataka (upto 30 June, 2012).	Chairman
Prof. P.L. Saroj, Director, DCR, Puttur - 574 202, Dakshina Kannada district, Karnataka (w.e.f. 1 September, 2012).	Chairman
Prof. P.L. Saroj, Assistant Director General (Hort.-I), ICAR, Krishi Anusandhan Bhavan-II, New Delhi - 110 012 .	Member
Dr. K.B. Dundi, Joint Director of Horticulture (Plantation Crops and Plant Protection), Directorate of Horticulture, Department of Horticulture, Lalbagh, Bengaluru-4, Karnataka.	Member
Additional Director of Horticulture (NHM), Tamil Nadu Horticulture Development Agency, Agriculture Complex, III Floor, Chepauk, Chennai-5, Tamil Nadu.	Member
Dr. M. Hanumanthappa, Associate Director of Research, Zonal Agricultural Research Station, Brahmavara, Udupi District, Karnataka.	Member
Dr. P. Shivarama Bhat, Principal Scientist (Agricultural Entomology), Directorate of Cashew Research, Puttur - 574 202, Dakshina Kannada, Karnataka.	Member
Dr. T.R. Rupa, Principal Scientist (Soil Science-Soil Physics & Soil & Water Conservation), Directorate of Cashew Research, Puttur-574 202, Dakshina Kannada, Karnataka.	Member
Dr. K.S. Ananda, Principal Scientist, Central Plantation Crops Research Institute, Regional Station, Vittal-574 243, Kerala.	Member
Dr. Anitha Karun, Principal Scientist, Division of Crop Improvement, Central Plantation Crops Research Institute, Kasaragod - 671 124, Kerala.	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
Sri. N. Narayana Bhat, Rtd. Bank Manager, Noojibailu House, Manchi Post, Bantwal Taluk, Dakshina Kannada, Karnataka.	Member
Senior Finance and Accounts Officer, Central Plantation Crops Research Institute, Kasaragod-671 124, Kerala.	Member
Administrative Officer, DCR, Puttur-574 202, Dakshina Kannada, Karnataka.	Member Secretary

The Institute Management Committee (IMC) met twice on 27 November, 2012 and 8 February, 2013. The activities of the Directorate were appraised to the IMC during the meetings. The equipments to be purchased and works to be undertaken during 2012-13 were discussed during the meeting.

17.3 Institute Research Committee

The 25th Institute Research Committee (IRC) was held during 19-20 June, 2012. Dr. M.G. Bhat, Director, DCR presented overview of DCR activities including salient achievements of different research projects. There were technical sessions on 'Crop Improvement' chaired by Dr. B. Sathyanarayana Reddy, Professor, College of Horticulture, Mudigere; 'Crop Management' chaired by Dr. N. Yadukumar, Former Principal Scientist (Agronomy), DCR, Puttur; 'Crop Protection' chaired by Dr. V.V. Belavedi, Professor, Department of Agricultural Entomology, UAS, Bengaluru; 'Post Harvest Technology' Chaired by Dr. M. Sivaswamy, Dean, Kelappaji College of Agricultural Engineering and Technology Kerala Agricultural University, Tavanur, Kerala and 'Transfer of Technology' chaired by Dr. M.G. Bhat. The scientists of the Directorate presented progress made under various projects and technical programme of all the projects was finalized.

17.4 Institute Joint Staff Council

Official side	
Dr. M.G. Bhat	Chairman (up to 30-6-2012)
Prof. P.L. Saroj	Chairman (w.e.f. 1-9-2013)
Dr. M.G. Nayak	Member
Dr. T.N. Raviprasad	Member
Shri. T.S. Ponnaiah	Member
Shri. K.M. Lingaraja	Member
Dr. D. Kalaivanan	Member Secretary
Staff side	
Ms. K. Padmini Kutty	Member Secretary
Ms. B. Jayashri	Member
Shri. Ravishankar Prasad	Member
Shri. K. Babu Poojari	Member (CJSC)
Shri. H. Veerappa Gowda	Member
Shri. B. Kushalappa	Member

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

18. DISTINGUISHED VISITORS

During the year several distinguished visitors including Dr. Kirti Singh, Former Vice-Chancellor and Chairman, ASRB, New Delhi; Dr. H.P. Singh, Former DDG (Hort.) and Dr. N.K. Krishna Kumar, DDG (Hort.), ICAR, New Delhi visited this Directorate.

Dr. N.K. Krishna Kumar discussed in detail about the ongoing research programmes at DCR and also took stock of the research work undertaken by the scientists since inception of the Directorate. The DDG (Hort.), in his remarks, expressed concern

about the low productivity of cashew in the country. He emphasized that the scientists should play a pivotal role in technology development and research coordination since DCR is the nodal organization

Visit of DDG (Hort.) to DCR

in the country involved in the cashew research and development. He expressed that a separate block need to be developed and maintained by integrating best performing variety and technologies developed at this Directorate, so as to maximize the per unit productivity of cashew in Southern Karnataka. He emphasized that some progrmames should be formulated as flagship programmes in the area of expertise to address the major problems of cashew. After in-depth interaction, two programmes *i.e.* (i) Maximization of cashew productivity and (ii) Integrated management of cashew pests, were proposed to take up in future. He categorically emphasized that the research priorities of XII Plan should be need based and target oriented. While formulating research strategy, there is a need to analyze the gaps in the cashew productivity and to suggest interventions in a focused manner. Dr. Krishna Kumar visited the laboratories, nursery and experimental farm.

The details of distinguished visitors are furnished below:

Name & Designation	Address	Date of visit
Dr. K.N. Vijaya Prakash Chief Executive Officer	Zilla Parishad, Dakshina Kannada, Mangalore.	7 April, 2012
Dr. Dharam Singh Assistant Director	National Horticulture Board Bengaluru.	16 May, 2012
Dr. Kirti Singh Former Vice-Chancellor and Chairman, ASRB	38G, Maruti Nagar TD College Gate, Husainbad Jaunpur-222 002, Uttar Pradesh.	28 June, 2012
Dr. H.P. Singh Deputy Director General (Hort.)	ICAR, KAB-II, Pusa New Delhi-110 012.	30 June 2012
Dr. N.K. Krishna Kumar Deputy Director General (Hort.)	ICAR, KAB-II, Pusa New Delhi-110 012.	29 October, 2012
Dr. Om Prakash Chief Consultant	National Horticulture Mission New Delhi.	11 January, 2013
Dr. A.K. Gupta Dean	College of Agriculture (SKRAU) Campus Lalsot, Rajasthan.	15 January, 2013
Dr. W.S. Dhillon Assistant Director, General (Hort.-I)	ICAR, KAB-II, Pusa New Delhi-110 012.	19 January, 2013
Dr. Umesh Srivatsava Assistant Director General (Hort.-II)	ICAR, KAB-II, Pusa New Delhi-110 012	6 March, 2013

19. PERSONNEL

19.1 Staff position as on 31.3.2013

Category	Sanctioned	Filled	Vacant
Director (RMP)	1	1	-
Scientific	17	13	4
Technical	19	17	2
Administrative	15	11	4
Canteen staff	1	1	-
Supporting	39	33	6
Total	**92**	**76**	**16**

19.2 Managerial

Dr. M.G. Bhat	Director (upto 30 June, 2012)
Dr. M.G. Nayak	Acting Director (upto 31 August, 2012)
Dr. P.L. Saroj	Director (w.e.f. 1 September, 2012)

19.3 Scientific

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

19.4 Technical

1. Sri. K. Muralikrishna	Farm Superintendent T (7-8)
2. Sri. P. Adbulla	Farm Superintendent T (7-8)
3. Sri. R. Arulmony	Technical Officer (Lib.) T (7-8)
4. Sri. A. Padmanabha Hebbar	Technical Officer (Elec.) (T-6)
5. Sri. Prakash G. Bhat	Technical Officer (T-6)
6. Sri. Lakshmipathi	Technical Officer (T-6)
7. Sri. R. Lakshmisha	Technical Officer (T-6)
8. Sri. K.V. Ramesh Babu	Technical Officer (T-6)
9. Sri. N. Manikandan	Technical Officer (T-5)
10. Sri. R. Muthuraju	Technical Officer (T-5)
11. Sri. K. Seetharama	Technical Officer (T-5)
12. Sri. A. Poovappa Gowda	Technical Officer (T-5)
13. Sri. K. Babu Poojary	Technical Assistant (T-3)
14. Sri. Ravishankar Prasad	Technical Assistant (T-3)
15. Sri. Vijay Singh	Technical Assistant (T-3)
16. Sri. Bejmi Veigus	Technical Assistant (T-2)
17. Sri. K. Umanath	Technical Assistant (T-2)
18. Sri. P. Honnappa Naik	Technical Assistant (T-1)

19.5 Administration

1. Sri. T.S. Ponnaiah	Administrative Officer	6. Ms. K. Reshma	Personal Assistant
2. Sri. K.M. Lingaraja	Assistant Administrative Officer (Establishment)	7. Ms. Winne Lobo	Assistant
3. Ms. M. Rathna Ranjani	Assistant Administrative Officer (Stores)	8. Ms. M. Leela	Assistant
4. Sri. O.G. Varghese	Private Secretary	9. Sri. Uma Shankar	UDC
5. Ms. B. Jayashree	Personal Assistant	10. Ms. Padmini Kutty	UDC
		11. Sri. K. Balappa Gowda	Gestetner Operator

20. MISCELLANEOUS

20.1 Budget (2012-13)

(₹ in lakhs)

Plan	Non-Plan	External	Total
126.32	486.69	7.05	620.06

20.2 Meteorological data at DCR, Puttur (2012-13)

Month	Temperature (°C)		Relative humidity (%)		Rainy days	Rainfall (mm)	Wind velocity (km/h)	Sunshine (h)	Pan evaporation (mm)
	Max.	Min.	7.28 h	14.28 h					
Apr. 2012	35.5	22.5	91	49	9	107.9	1.4	6.3	4.9
May 2012	35.3	23.2	90	50	2	31.4	1.2	6.0	4.4
Jun. 2012	31.3	23.0	93	79	24	757.0	1.1	1.8	3.2
Jul. 2012	30.8	23.2	94	79	25	590.5	1.9	2.4	2.7
Aug. 2012	28.1	22.6	93	81	27	926.8	1.2	2.2	2.9
Sep. 2012	31.5	22.6	94	71	19	311.2	1.0	4.0	3.3
Oct. 2012	31.7	22.9	92	61	7	190.0	0.8	4.7	3.5
Nov. 2012	33.8	20.4	89	45	3	4.0	0.3	7.8	3.6
Dec. 2012	34.1	20.3	85	41	0	0.0	0.7	8.1	3.7
Jan. 2013	34.7	18.9	90	34	0	0.0	0.6	8.7	3.9
Feb. 2013	35.3	21.2	89	39	2	12.2	1.5	8.0	4.3
Mar. 2013	36.2	23.2	90	43	0	5.0	2.7	7.1	5.1
				Total rainfall		**2936.0**			

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

20.3 List of DCR publications

Sl. No.	Publication	Price (₹)
1	Cashew production technology (Revised)	60.00
2	Softwood grafting and nursery management in cashew (Revised)	45.00
3	Annotated bibiliography on cashew (1985-1994)	75.00
4	Catalogue of minimum descriptors of cashew	
	Germplasm accessions - I	165.00
	Germplasm accessions - II	125.00
	Germplasm accessions - III	128.00
5	Status of cashew germplasm collection in India (Booklet)	
6	Compendium of concluded research projects (1986 -2001)	
7	Sudharitha geru besaya kramagalu (Booklet in Kannada)	15.00
8	Cashew nutritive value (Revised) (Brochure)	
9	Database on cashewnut processing in India (2003)	100.00
10	Directory of cashewnut processing industries in India (2003)	100.00
11	Process catalogue on development of economically viable on-farm cashewnut processing	45.00
12	Cashew cultivation practices (Pamphlet)	
13	Annotated bibliography on cashew 1995-2007	205.00
14	Soil and water management in cashew plantations	30.00
15	Biochemical characterization of released varieties of cashew	85.00
16	Pruning and canopy architecturing in cashew	40.00

Price indicated above does not include postage.

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


भाकृअनुप
ICAR
हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद
Agrisearch with a human touch