

# वार्षिक प्रतिवेदन ANNUAL REPORT

2011 - 12



**काजू अनुसंधान निदेशालय**

भारतीय कृषि अनुसंधान परिषद

करीम नगर, पुणे - 574 202, महाराष्ट्र, भारत

**DIRECTORATE OF CASHEW RESEARCH**

(Indian Council of Agricultural Research)

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ICAR

**DIRECTORATE OF CASHEW RESEARCH**

(Indian Council of Agricultural Research)

Dakshina Kannada, Karnataka

Darbe P.O., Puttur - 574 202



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## प्रस्तावना

मुझे काजू अनुसंधान निदेशालय, पुत्तूर का वार्षिक प्रतिवेदन 2011 - 12 प्रस्तुत करने में खुशी होती है, जिसमें अप्रैल 2011 तक का प्रगति सम्मिलित है। इस निदेशालय का वैज्ञानिकों ने फसल सुधार, फसल प्रबंधन, फसल संरक्षण, कटाई उपरान्त प्रौद्योगिकी तथा तकनीकी हस्तांतरण का क्षेत्रों में अनुमोदित तकनीकी कार्यक्रमों के तहद परियोजनाओं को प्रचालित किए हैं और उसमें पाए गए परिणामों तथा उपलब्धियों को इस वार्षिक प्रतिवेदन में प्रस्तुत की गई है।

इस साल उन्नीस जीवनद्रव्य एक्सशनों को IPGRI वर्णको के आधार पर मूल्यांकित करने से अब तक राष्ट्रीय काजू जीन बैंक (NCFGB) में संग्रहित 527 एक्सशनों में से खुल 452 मूल्यांकित किए गए हैं। आठवी कटाई में भी आशाजनक हैब्रीडो : H - 68, H - 125 तथा H - 126 उत्कृष्ट रहा, उल्लाळ - 3 तथा भास्करा जैसे किस्मों ने सांद्र रोपण पद्धति (500 प/हे) में उत्तम संचर्च उपज देकर श्रेष्ठता प्रदर्शित किया। यूरिया (3%)+ H<sub>3</sub>PO<sub>4</sub> (0.5%)+K<sub>2</sub>SO<sub>4</sub>(1%) का पर्णी चिडकाव से द्विलिंगी पुष्प संख्या तथा गुटली उपज सुधारित हुआ। कम उम्र और बड़ा उम्र का काजू वागानो में जीवउर्वरक संकाय तथा FYM और शिफारित उर्वरक मात्रा से गुटली उपज बड़ सका। काजू कांड और जड़ छेदक (CSRB); फलेसिडेस प्रभेदों की सूंझियों पर हेटिरोराडैटिस इंडिका, स्टीनरनीमा अब्बासी और स्टीनरनीमा बैकारनूटम जैसे कीटरोगजनक गोलक्रीमियों (EPN) सांघातिकता दिखाई। भारत के विविध भूप्रदेशों से संग्रहित कीटनमूनों से चार प्रभेदों का चाय मच्छर यानि हेलोपेल्टीस ऑटनी, हेलोपेल्टीस ब्राडी, हेलोपेल्टीस थीवोरा और प्याकिपेल्टीस मीसारम का जीववर्गीकरण किया गया है। मकडीयों का हलचल के बारे में निरीक्षण जारी रहा और अधिक संख्या की मकडीयों को काजू वागानो से संग्रहित किया गया। संघन "इस रोस्टिंग" यंत्र, संकेद्रित ड्रम टायर्य प्ररिभ्रामिक ग्रेडर तथा सुघरित यात्रीकृत शेल्लींग यंत्र का मूल्यांकन किया गया ताकि कच्छा काजू गुटलीयों का संस्करण में अपेक्षित बदलाव लासके। इस निदेशालय ने DCCD, कोच्ची के सहयोग से प्रदर्शनी प्लाटो को प्रचालित करके उनका निरीक्षण किया, वैज्ञानिक समूहों द्वारा तकनीकी सुझाव दिया गया।

इस निदेशालय ने "काजू खेती दिवस" तथा "वार्षिक काजू दिवस" आयोजित किया, जिसने बहुसंख्या में किसानों तथा अधिकारियों को आकर्षित किया। अपने पच्चीस साल के उपयुक्त अस्तित्व और किसानों तथा विकास विभागों का सेवा देने के उपलक्ष्य में इस निदेशालय 23 - 24 दिसंबर 2011 को रजत महोत्सव समारोह (1986 - 2011) मनाया गया। इस संदर्भ में काजू पर "राष्ट्रीय विशेषज्ञों परामर्श" और "राष्ट्रीय स्तर का काजू पणघारी बैठक" भी आयोजित किया गया जिसमें वैज्ञानिकों, तकनीकी विशेषज्ञों, संसाधकों तथा काजू किसानों को मिलाकर 300 से अधिक प्रतिनिधियों भाग लिए।

मैं वर्ष 2011 - 12 का वार्षिक प्रतिवेदन के संकलन करने के लिए संपादकीय समिति के सदस्यों को आभारी हूँ।

एम. गोपालकृष्ण भट्ट

(एम. गोपालकृष्ण भट्ट)

निदेशक

स्थल : का. अ. नि., पुत्तूर

दिनांक : 25 जून 2012

## PREFACE

I am glad to present the Annual Report 2011-12 of Directorate of Cashew Research, Puttur in which progress of the Directorate for the period from April, 2011 to March, 2012 are covered. Different projects in the areas of Crop Improvement, Crop Management, Crop Protection, Post-Harvest Technology and Transfer of Technology have been implemented by the Scientists of this Directorate as per the approved technical programme. The results of these projects along with findings of concluded projects are reported in this Annual Report.

During the year, nineteen germplasm accessions planted in 2000-01 were characterized as per IPGRI descriptors bringing the total number of accessions evaluated to 452 out of 527 accessions maintained in National Cashew Field Gene Bank. The promising hybrids H-43, H-66, H-68, H-125 and H-126 continued to excel even during eighth harvest. The varieties such as Ullal-3 and Bhaskara performed better in high density system of planting (500 plants/ha) with better cumulative yield. Foliar application of major nutrients viz., urea (3%) + H<sub>3</sub>PO<sub>4</sub>(0.5%) + K<sub>2</sub>SO<sub>4</sub>(1%) helped in improved bisexual flower production and nut yield/tree. Application of biofertilizer consortia along with FYM and recommended dose of fertilizers resulted in higher nut yield in both young and mature cashew plantations. The entomopathogenic nematodes (EPN), *Heterorhabditis indica*, *Steinernema abbasi* and *Steinernema bicornutum* were virulent against grubs of cashew stem and root borers (*Plocaederus* spp). The biosystematics of four species of tea mosquito bug viz., *Helopeltis antonii*, *H. bradyi*, *H. theivora* and *Pachypeltis maesarum* has been studied utilizing collections made from different geographical locations in India. The monitoring of the activity of spiders was continued and large number of spider species was collected from cashew plantations. The performance evaluations of compact type drum roasting machine, concentric drum type rotary grader and improved mechanized shelling machine have been carried out with an view to bring about desired changes in processing of raw cashewnuts. The Directorate continued its collaboration with DCCD, Kochi and the demonstration plots laid out with its collaboration were monitored and technical advice was offered by the group of scientists from this Directorate. The Directorate has organized Cashew Field Day and Annual Cashew Day which attracted large number of farmers and officials from Kerala and Karnataka.

The Silver Jubilee Celebrations (1986-2011) of this Directorate of Cashew Research was held during 23-24 December, 2011 to commemorate the completion of 25 years of useful existence and having served the farmers and development departments. As a part of Silver Jubilee Celebrations, a 'National Expert Consultation on Cashew' and a 'National Cashew Stakeholders Meet' were organized in which around 300 delegates including scientists, technical experts, processors and cashew farmers participated.

I am thankful to members of Editorial Committee for the compilation of the Annual Report 2011-12.

(M. Gopalakrishna Bhat)

Director

Place : DCR, Puttur  
Date : 25 June, 2012

## कार्यकारी सारांश

सन् 2011-12 में NAIP और ICAR नेटवर्क परियोजनाओं को मिलाकर खुल 22 परियोजनाओं इस निदेशालय में प्रचालित थे। इस साल में रोपित 19 जीवनद्रव्य एकसशनों को मूल्यांकन, तथा IPGRI वर्णकों के आधार पर प्रवर्धन, उपज व गुटली लक्षणों का चरित्रवर्णन करने से NCFGB में संरक्षित 527 एकसशनों में 452 एकसशनों का मूल्यांकन हुआ है। काजू में विभिन्नता, समानता और स्थिरता (DUS) परीक्षणों का मार्गदर्शी सूत्रों को बदल के अध्ययन करके विचारणात PPV & FR, नई दिल्ली को प्रेषित किया गया।

H-43, H-66, H-68, H-125 और H-126 जैसे आशाजनक हैब्रिडों में क्रमशः 42.63, 42.61, 43.03, 46.10 और 42.39 कि.ग्रा./पेड का आठ साल का संचयी उपज और 7.3, 8.0, 7.5, 8.5 तथा 8.0 कि. ग्रा./पेड का वार्षिक उपज दिया। RAPD, ISSR व SSR मार्करों के तहद 45 जीवनद्रव्य एकसशनों का चरित्रवर्णन की गयी है और इनमें 0.64 से 0.98 तक की समानरूपता गुणांकमूल्य पाया गया और औसत विभिन्नता 0.84 रहने से एकसशनों में कम भिन्नता सूचित किया। सधन रोपण पद्धति में (5 x 5 मी) 500 पेड / हे, का रोपण का अत्यधिक संचयी उपज, उल्लाळ - 3 (4213 कि.ग्रा. / हे) और भास्करा में (3648.00 कि. ग्रा. / हे) पाया गया। यूरिया (3%), H<sub>3</sub>PO<sub>4</sub> (0.5%) और K<sub>2</sub>SO<sub>4</sub> (1.0%) का पर्णीय चिडकाव से अत्यधिक द्विलिंगी पुष्पसंख्या तथा गुटली उपज दखिल हुआ। लघु और द्वितीयक पोषकांश यानि ZnSO<sub>4</sub> (0.5%) + MgSO<sub>4</sub> (0.5%) + साल्यूबोर (0.1%) उपचरित पेडों में भी समानरूप प्रवृत्ति सूचित हुआ।

अनुपचरित पेडों की पोर का अन्तर (25.0 मि.मी) रहा जो प्याक्लोब्युट्रसाल उपचार में सतर्क रूप से कम रहा (5.9 - 12.0 मि. मी) कम उमर (5 साल) और बडा (12 साल) काजू पेडों में जीवउर्वरक संकाय (अजोस्यैरुल्लेम, अजटोब्याक्टर और रंजक विलयशील व्याकटीरिया व AMF

(जडसंयुक्त कवक जाल) संचारण और 100% NPK + FYM लगाने से गुटली उपज 5 साल तथा 12 साल उम्र के पेडों में क्रमशः 2.52 और 10.52 कि.ग्रा. / पेड रहा। पॉटिंग - मिश्रण में जैवउर्वरक संकाय मिलाने से प्रकन्द / कलमो स्वस्थ और तन्दुरुस्त रहा।

काजू कांड और जड छेदक (CSRB) प्लोसिडेरस प्रभेध की सूडियो पर हेटरोराडैटिस इंडिका, स्टीनरनीमा अब्बासी और स्टीनरनीमा वैकारनूटम जैसे कीटरोगजनक गोलक्रिमियो (EPN) का सांधातिकता का जाँच किया गया और इन EPN प्रभेधो ने क्रमशः 14.11, 12.88 और 12.37 दिनों का औसत समय में मर्त्यता उत्पन्न किया। अनुरूपी परिस्थितियों में 150 दिनों के बाद भी स्टीनरनीमा वैकारनूटम चारा-कीट (मोम-पतंग) का 50 प्रतिशत से ज्यादा औसत मर्त्यता उत्पन्न किया। भारत के विविध भूप्रदेशो से विभिन्न अतितेय पौधो से हेलेपेल्टीस ऑन्टनी, हे. ब्राडी, हे. थीवोरा और प्याकिपेल्टीस मीसारम को आण्विक विभिन्नता अद्ययन के लिए संग्रहित किया गया। मैटोकांड्रियल सैटोक्रोम आक्सिडेस -1 (COX-1) को व्यक्तिक कीटो से सफलतापूर्वक अनुक्रमित किया गया। हे. ऑन्टनी और हे. ब्राडी के बीच मे खुल 658 आधार जोडी (bp) न्यूक्लियोटाईड में से 50 न्यूक्लियोटाईडो विभिन्नता मिला जो 7.60 प्रतिशत था। उसी तरह, हे ऑन्टनी और हे. थीवोरा के बीच मे 72 न्यूक्लियोटाईड में विभिन्नता मिला जो 10.94 प्रतिशत रहा। मकडीयो का हलचल की बारे मे निरीक्षण इस साल भी जारी रहा और काजू बगानो में पुराने साल मे संग्रहित 24 प्रभेधो के साथ और 20 नया प्रभेधो को संग्रहित किया गया। इन प्रभेधो ने अरेनिडे, ग्नाफोसिडे, आक्सियोपिडे, साल्टिसिडे, स्पारासिडे, टेड्रानातिडे और तैरिडियो कुटुंब का सदस्य थे।

संघन ड्रम टाईप रोस्टिंग यंत्र को विकसित किया गया और प्रत्येक कच्छ गुटली का परिमाण तथा प्रभावन समय के लिए सेंकन तापमान बडाने से सोंकित गुटली का

कठोरता कम हुआ। संकेंद्रित ड्रम टाईप प्ररिभ्रामिक ग्रेडर को स्क्रीन लंबाई, परिभ्रामिक रफ्तार, राशि सांद्रता, बेलन कोन तथा भरण दर जैसे विचारों का निष्पादन किया गया। बाष्प उपचारित कच्चा गुटली के संबंध में सुधारित छिलकन यंत्र का निष्पादन मूल्यांकित किया गया।

इस निदेशालय के वैज्ञानिक समूहों द्वारा इस वर्ष के दौरान DCCD के NHM कार्यक्रम के तहत दिया गया आर्थिक सहायता से लिए गए प्रदर्शनी प्लाटों का निरीक्षण किया गया और तकनीकी सुझाव दिया गया। इस निदेशालय के स्थापना दिवस के संदर्भ में, नवीनप्रक्रिया अनुशोधक काजू किसानों का बैठक आयोजित करके उस अवसर पर ऐसे काजू किसानों को सम्मानित किया गया। इस निदेशालय ने अपने 25 साल के उपयुक्त अस्तित्व तथा किसानों और विकास विभागों को सुधारित काजू उत्पादन तकनीकी विकसित करके सेवा देने के उपलक्ष में 23-24 दिसंबर 2011 को इस निदेशालय के रजत महोत्सव DCR, पुत्तूर में मनाया गया।

इस अवसर पर “काजू पर राष्ट्रीय विशेष ज्ञ परामर्श” को “काजू का गुणवत्ता तथा अधिक उत्पादकता के लिए चुनौतियां तथा चतुराईयाँ” के विषय पर संगोष्ठी आयोजित किया गया और साथ ही साथ “राष्ट्रीय स्तर का पणघारि बैठक” भी आयोजित किया गया। इस समारोह में वैज्ञानिकों, तकनीकी, विशेषज्ञों, संसाधकों तथा काजू किसानों को मिलाकर लगभग 300 प्रतिनिधियाँ भाग लिया। दिनांक 29 फरवरी 2011 को बंटवाळा स्थित मंची ग्राम में काजू खेती दिवस आयोजित था। वार्षिक काजू दिवस को इस निदेशालय में 9 मार्च 2011 को मनाया गया। BAIF विकास व अनुसंधान फौंडेशन, पुणे के विनती पर वैज्ञानिकों का टीम ने गुजरात में स्थित काजू बागानों का निरीक्षण करके कम उपज का कारणों का जाँच किया और उपज सुधारने हेतु उपाय बताया। इस साल में तीन लाख काजू कलमों को कृषकों तथा विकास विभागों को वितरित किया। इस निदेशालय में प्रचलित अनुसंधान परियोजनाओं का परिणामों का विवरण इस वार्षिक प्रतिवेदन में प्रस्तुत किया है।



## EXECUTIVE SUMMARY

A total of 22 projects including one NAIP project and one ICAR Network project were in operation at Directorate of Cashew Research during 2011-12. During the year, 19 germplasm accessions planted in 2000-01 were evaluated and characterized as per IPGRI descriptors for their growth, yield and nut characters bringing the total number of accessions evaluated to 452 out of 527 accessions maintained in National Cashew Field Gene Bank (NCFGB). Distinctness, Uniformity and Stability (DUS) testing guidelines for cashew were modified and updated and forwarded to Protection of Plant Varieties and Farmers Right Authority (PPV & FRA), New Delhi for consideration. The promising hybrids H-43, H-66, H-68, H-125 and H-126 yielded 7.3, 8.0, 7.5, 8.5 and 8.0 kg/tree, respectively with a cumulative yield of 42.63, 42.61, 43.05, 46.10 and 42.39 kg/tree, respectively for eight harvests. Forty five accessions of cashew germplasm were characterized using RAPD, ISSR and SSR markers and the similarity coefficient values varied from 0.64 to 0.98 with an average diversity of 0.84 indicating the existence of low diversity among the accessions.

In the high density system of planting with 500 plants/ha (5m x 5m), cumulative yield (2008-12) was highest in Ullal-3 (4213 kg/ha) followed by Bhaskara (3648 kg/ha). Of the major nutrients evaluated, urea (3%) + H<sub>3</sub>PO<sub>4</sub> (0.5%) + K<sub>2</sub>SO<sub>4</sub> (1%) recorded the highest number of bisexual flowers and nut yield/tree. Similar trend was noticed with secondary and micronutrients ZnSO<sub>4</sub> (0.5%) + MgSO<sub>4</sub> (0.5%) + Solubor (0.1%) treated plants. Application of paclobutrazol reduced plant vigour as there was significant reduction in internodal length (5.9 to 12 mm) compared to control (25 mm). Application of biofertilizer consortia (*Azospirillum*, *Acetobacter*, Phosphate solubilizing bacteria and

AMF with 100% NPK+FYM resulted in nut yield of 2.52 and 10.52 kg/tree in young and mature cashew plantations. Application of biofertilizer consortia at the time of preparation of potting mixture and the root stock / grafts of cashew raised by using this mixture resulted in very vigorous and healthy growth.

The virulence of entomopathogenic nematodes (EPN), *Heterorhabditis indica*, *Steinernema abbasi* and *Steinernema bicornutum* against grubs of cashew stem and root borers (*Plocaederus* spp). was studied and these species of EPN induced mortality in a mean duration of 14.11, 12.88 and 12.37 days, respectively. *Steinernema bicornutum* induced more than 50 per cent of mean mortality of the bait species (wax moth) even after 150 days under simulated conditions. *H. antonii*, *H. bradyi*, *H. theivora* and *Pachypeltis maesarum* were collected from different geographical locations in India on different host plants for molecular diversity studies. Mitochondrial cytochrome oxidase-1 (COX-1) was successfully sequenced from 32 individuals. Pair wise alignment of *H. antonii* and *H. bradyi* showed variation in 50 nucleotides out of 658 bp, amounting to a difference of 7.6 per cent. Similarly, between *H. antonii* and *H. theivora*, there was a variation in 72 nucleotides out of 658 bp amounting to 10.94 per cent. The monitoring of the activity of spiders was continued and another 20 species were recorded in cashew plantations in addition to the 24 species recorded earlier. These species belonged to the families araneidae, gnaphosidae, oxyopidae, salticidae, sparassidae, tetragnathidae and theridiidae.

A compact type drum roasting machine was developed and it was observed that hardness of roasted cashewnuts decreased with increased roasting

temperature for a raw nut of particular size and exposure period. Performance of concentric drum type rotary grader was evaluated in terms of screen length, rotational speed, bulk density, cylinder angle and feed rate. Performance of improved mechanized shelling machine was evaluated for steam treated raw cashewnuts.

During the year, demonstrations plots laid out with financial support of National Horticulture Mission (NHM) programme of Directorate of Cashewnut and Cocoa Development (DCCD), Kochi were monitored and technical advice was offered by the group of scientists from this Directorate. On the occasion of Foundation Day of the Directorate, innovative cashew farmers meet was organized and innovative cashew farmers were felicitated.

The Silver Jubilee Celebrations (1986-2011) of Directorate of Cashew Research (DCR) was held during 23-24 December, 2011 at its headquarters DCR, Puttur to commemorate the completion of 25 years of useful existence and having served the farmers and development departments by developing several improved cashew production technologies.

As a part of Silver Jubilee Celebrations, a 'National Expert Consultation on Cashew' with the theme 'Challenges and Strategies for Higher Productivity and Quality of Cashew' and a 'National Cashew Stakeholders Meet' were organized. Around 300 delegates including scientists, technical experts, processors and cashew farmers participated in the Celebrations.

A Cashew Field day was organized on 29 February, 2012 in Manchi village of Buntwal taluk in association with three cashew demonstration farmers. Annual Cashew Day was organized on 9 March, 2012 in which more than 250 farmers participated.

A team of scientists visited the cashew plantations in Gujarat on request from BAIF Development Research Foundation, Pune which studied the causes for low yield and suggested measures for improvement. During the year, around three lakh cashew grafts were distributed to farmers and Development Departments. The details of results of the ongoing research projects of the Directorate are presented in this Annual Report.



## 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 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 (AICRP - Cashew) was shifted to DCR, Puttur. At present, this Coordinated Research Project is operating at ten Centres and a Sub Centre distributed in major cashew growing areas of the country. There are three Co-operating Centres also.

### 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.

### ORGANIZATIONAL SET UP AND INFRASTRUCTURE

- Directorate of Cashew Research is located at Puttur, Dakshina Kannada, Karnataka. The main campus 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 and AGRIS, SOIL CD, CROP CD, PLANTGENE CD and TROPAG CD are also available in the library. The library has equipped with automation software and bar coding facility. The library has 1240 books and 1601 back volumes of various journals. The library subscribes 35 National and 18 International journals. The library is a member of Consortium of Electronic Resources on Agriculture (CeRA), New Delhi. Tech-Focus digital library software is also available for CD Database search.
- The Headquarters of AICRP - Cashew is located at DCR, Puttur. It has ten Coordinating Centres located in Karnataka, Kerala and Maharashtra in

West Coast, Andhra Pradesh, Orissa, Tamil Nadu and West Bengal in the East Coast and in Chattisgarh, Gujarat and Jharkhand and a Sub-Centre at Pilicode (Kerala). There are three Co-operating Centres in Arabhavi (Karnataka), Old Goa (Goa) and Barapani (Meghalaya).

### SIGNIFICANT ACHIEVEMENTS

- The Directorate has the largest germplasm collection of cashew in the country (National Cashew Field Gene Bank) with 527 accessions. A total of 433 cashew accessions have been assigned with National Collection numbers. The Conservation Block of Gene Bank has been established with 362 evaluated accessions by planting four plants of each accession.
- It has released three varieties, namely, NRCC Sel-1, NRCC Sel-2 and Bhaskara, which are high yielding and medium nut types for cultivation in Karnataka.
- Regeneration of cashew from the seedling explants (nodal cultures) has been standardized.
- Micrografting technique for *in vitro* multiplication of cashew has been standardized.
- Protocols have been standardized for characterization of released varieties and cashew germplasm accessions using RAPD, ISSR and SSR markers.
- The Directorate has demonstrated the advantage of growing intercrops like pineapple, turmeric, brinjal, chillies and amorphophallus profitably in cashew gardens.
- Glyricidia grown as an intercrop during initial years contributed 5.75 t/ha of dry matter, equivalent to 186 kg N, 40.8 kg P<sub>2</sub>O<sub>5</sub> and 67.8 kg K<sub>2</sub>O/ha. The yield of cashew increased by 50 per cent when glyricidia and sesbania were raised as green manuring crops compared to control. Glyricidia is however recommended as the best green manure crop due to its perennial nature.
- Application of 200 g *Azospirillum* plant with 33 kg of compost of recyclable cashew biomass yielded 12 per cent higher compared to recommended dose of inorganic fertilizer. The yield increase was 38 per cent over the control plot (without biofertilizer, compost of recyclable cashew biomass and inorganic fertilizer).
- High density planting at a spacing of 4m x 4m (625 plants/ha) is better than normal spacing of 8m x 8m (156 plants/ha) resulting in yield increase by 2.5 times over control in the initial ten years.
- Irrigating cashew at 60-80 litres of water/tree once in four days through drip after initiation of flowering till fruit set and development in combination with the application of 750: 187.5: 187.5 g of NPK/tree led to significant higher yields.
- Individual tree terracing with crescent bund is the best soil and water conservation measure in slopy lands. Soil and water conservation techniques like modified crescent bund or staggered trenches with coconut husk burial treatments helps in conserving soil moisture, reducing the annual runoff / soil loss and increasing the nut yield.
- Drip irrigation and fertigation requirements have been standardised for normal planting system (200 trees/ha). Drip irrigation @ of 60-80 litres of water/ tree, once in four days from December to March, amounting to 1800-2400 litres of water/ tree has been found optimum.
- Softwood grafting method has been standardized and utilized for commercial multiplication of cashew grafts.
- Rearing technique for cashew stem and root borer (CSRB) on host bark has been standardized.
- Phytosanitation of cashew orchards by uprooting all the infested trees reduces the level of CSRB incidence at a given location.
- Chlorpyrifos (0.2%) is effective as post-treatment prophylaxis measure against CSRB.
- Volatiles and extracts in n-hexane from both healthy bark and frass on testing by EAG (Electroantennogram) elicit response from adult female beetles of CSRB.
- Laboratory rearing technique for tea mosquito bug (TMB) has been standardized in various host

plants.  $\lambda$ -cyhalothrin (0.003%) and fenprothrin (0.02%) were effective in reducing the damage of TMB under field condition.

- Residues of insecticides used for the management of pests of cashew were not detected in the kernels. The cashew apples can be collected from the sprayed plots after 15 days of spraying as they were free from residues of insecticide.
- Sweetened and flavoured spread could be prepared from cashew kernel baby bits. Cashew kernel baby bits could be coated with different combinations of flavour and colours. Cardamom flavoured and apple green / saffron coloured and sweetened cashew kernel baby bits are the most preferred. Sweetened and flavoured cashew kernel baby bits have shelf life of 12 months at ambient temperature.
- Mineral composition of defatted cashew kernel flour, testa and cashew apple pomace of released varieties vary. Mineral composition of cashew apple pomace could be improved by blending with defatted flours of either cashew or almond.

- Cashew apple powder lipids are rich in unsaturated fatty acids and the major fatty acids are palmitoleic and oleic acids. Treatment of cashew apple with salt reduces the tannin content of cashew apple powder. Antioxidant activity in the cashew apple is associated with tannin, phenols, sugars, ascorbic acid and amino acids. Cashew apple powder could be blended with cereal flour upto 20 per cent.
- Bioavailability of Fe and Zn in defatted cashew kernel flour is less compared to Cu, Mn and Se.
- Impact of transfer of technology (TOT) are assessed and strategies have been suggested for refining the TOT efforts.
- Yield forecasting model for predicting cashew yield has been developed.
- The Directorate has established very good linkage with farmers and officials of State Departments and Development Agencies.

### BUDGET (2011-12)

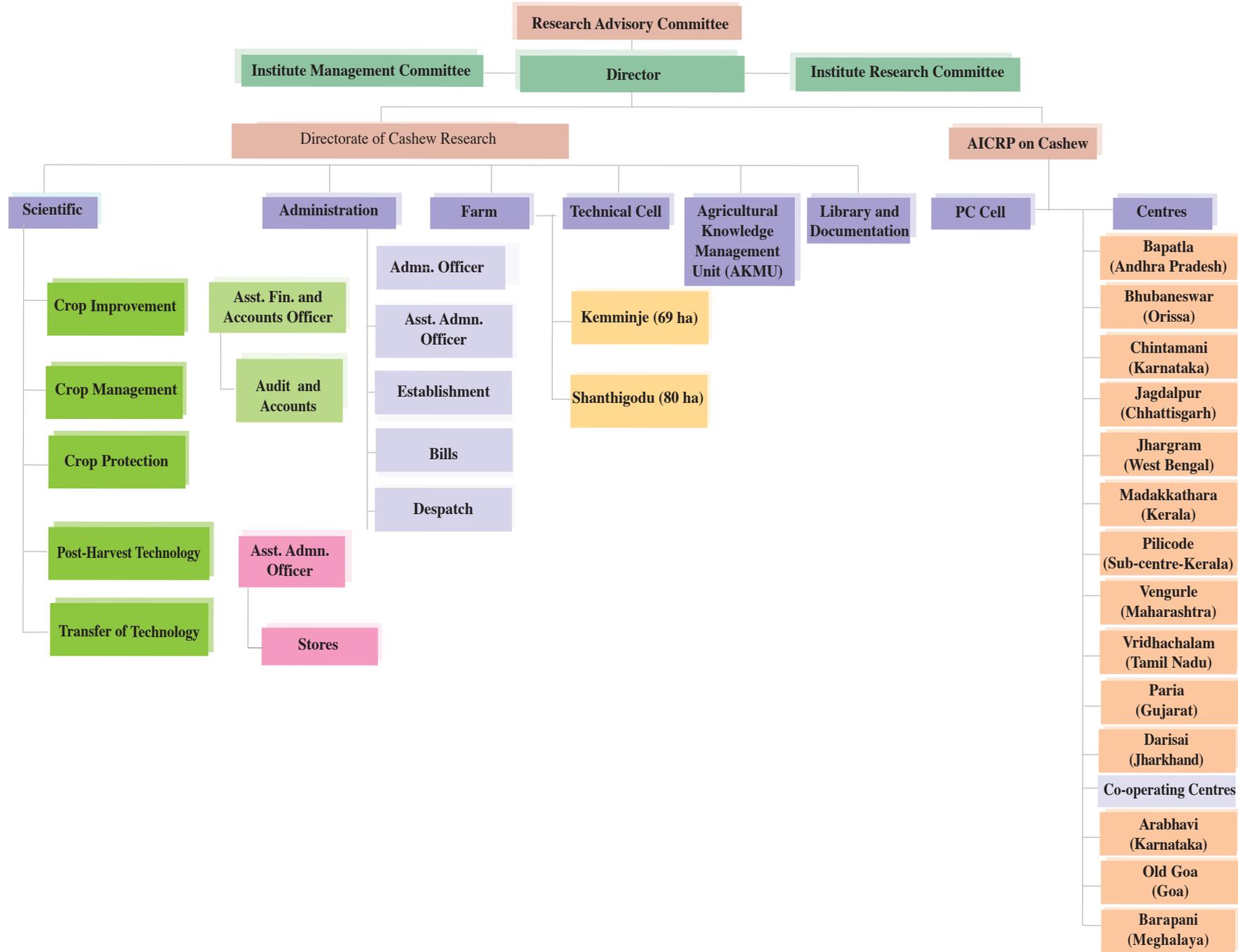
(₹ in lakhs)

Plan	Non-Plan	External	Total
259.00	359.00	5.72	623.72

### STAFF POSITION AS ON 31.3.2012

Category	Non-Plan		
	Sanctioned	Filled	Vacant
Director (RMP)	1	1	-
Scientific	17	12	5
Technical	19	18	1
Administrative	15	11	4
Skilled support staff	39	35	4
Canteen	1	1	-
<b>Total</b>	<b>92</b>	<b>78</b>	<b>14</b>

# ORGANIZATIONAL SETUP OF DCR, PUTTUR



# RESEARCH ACHIEVEMENTS

## 1. CROP IMPROVEMENT

### 1.1 Genetic resources of cashew

#### 1.1.1 Germplasm survey

Random cashew germplasm survey for locating tolerant types to Tea Mosquito Bug (TMB) was continued along with inspection / advisory visits in Karnataka Cashew Development Corporation (KCDC) plantation in Karnataka, Goa Forest Development Corporation (GFDC) plantations in Goa and a few stray plants / plantations in South Gujarat (Dang, Navsari and Valsad districts). Three plants which were already identified during previous season *viz.*, one in Kundapur division of KCDC plantation, one in Vridhachalam, Tamil Nadu and other one in GFDC plantations near Goa were also observed during the year for tolerance. The tolerance could not be measured or assessed as there was very low pest incidence during the year. Germplasm collection was done from Cashew Research Station, Jagdalpur, Chattisgarh and planted in Conservation Block of National Cashew Field Gene Bank (NCFGB).

#### 1.1.2 Germplasm evaluation

During current fruiting season 19 germplasm accessions which were planted during 2000-01 were

evaluated as per IPGRI descriptors (Table 1.1). The growth characteristics, yield and yield attributes were recorded while the nut characteristics, shelling percentage and kernel quality are being recorded. Among the 19 germplasm accessions evaluated 18 were upright branching and open canopy types with extensive branching behaviour, club shaped (57%) and oval shaped leaves (43%). Majority (95%) were mid season flowering having yellow coloured tender leaves.

Among the evaluated accessions nine had yellow coloured apple while others had red coloured apples. The fruit shape varied from cylindrical (42%), conical or obovate (37%) and the pyriform (21%) with big size apples (73%) having above 52 g weight. Higher nut weight (>7g) was recorded in 12 germplasm accessions while others had low nut weight with medium nut to apple ratio. Shell thickness and kernel weight were intermediate in more than 90 per cent of the accessions. Majority of accessions (90%) had loose attachment of peel to kernel. All the accessions had low cumulative yield.

**Table 1.1: Important features of germplasm accessions evaluated during 2011**

Data Field	Descriptor	Descriptor state	No. of accessions
7	Tree habit	3 Upright and compact	1
		5 Upright and open	18
		7 Spreading	0
9	Leaf shape	1 Oblong	0
		2 Obovate (Club-shaped)	11
		3 Oval	8
16	Branching pattern	1 Extensive	18
		2 Intensive	1
19	Colour of young leaves	1 Red	3
		2 Yellow red	10
		3 Green red	6
		4 Purple	0

28	Season of flowering	3	Early (Nov-Dec)	1
		5	Mid (Dec-Jan)	18
		7	Late (Jan-Feb)	0
31	Mature cashew apple colour	1	Yellow	9
		2	Yellow red	9
		3	Red purple	1
		4	Red purple	0
32	Shape of cashew apple	1	Cylindrical	8
		2	Conical-Obovate	7
		3	Round	4
		4	Pyriiform	0
50	Attachment of nut to cashew apple	3	Loose	4
		5	Intermediate	9
		7	Tight	6
35	Nut weight	3	Low (<5 g)	2
		5	Intermediate (5-7 g)	5
		7	High (>7 g)	12
43	Weight of cashew apple	3	Low (<27 g)	0
		5	Medium (27-52 g)	5
		7	High (>52 g)	14
60	Flowering duration	3	Short (<60 days)	4
		5	Medium (60-90 days)	15
		7	Long (>90 days)	0
62	Apple nut ratio	3	Low (<6)	1
		5	Medium (6-12)	18
		7	High (>12)	0
63	Shelling percentage	3	Low (<18 %)	0
		5	Intermediate (18-28 %)	10
		7	High (>28 %)	9
64	Kernel weight	3	Low (<1.2 g)	0
		5	Intermediate (1.2-2.5 g)	18
		7	High (>2.5 g)	1
57	Shell thickness	3	Thin (<2.5 mm)	0
		5	Intermediate (2.5-4.0 mm)	19
		7	Thick (>4.0 mm)	0
65	Attachment of peel to kernel	3	Loose	17
		7	Tight	2
68	Cumulative yield per plant (6 annual harvests)	3	Low (<9 kg)	19
		5	Medium (9-18 kg)	0
		7	High (>18 kg)	0

### 1.1.3 Distinctness, uniformity and stability (DUS) guidelines

DUS testing guidelines which were earlier discussed in the meeting organized by protection of plant varieties and farmers right authority (PPV & FRA) at CPCRI, Kasaragod were further modified and updated as per the suggestions in the meeting and forwarded to PPV & FRA, New Delhi.

## 1.2 Genetic improvement of cashew for yield and quality traits

### 1.2.1 Evaluation of hybrids

The promising hybrids, H-43, H-66, H-68 (cross combinations of NRCC Sel-2 x Bhuthnath-II),

H-125 and H-126 (cross combinations of NRCC Sel-2 x Bhedasi) yielded 7.3, 8.0, 7.5, 8.5 and 8.0 kg/tree, respectively with a cumulative yield of 42.63, 42.61, 43.05, 46.10 and 42.39 kg/tree, respectively over 8 harvests (Table 1.2).

### 1.2.2 Performance of hybrids (Replicated trial)

Among the hybrids, under replicated trial, the plant height ranged from 2.74 m to 4.51 m, stem girth ranged from 26.52 cm to 44.58 cm while, the canopy spread ranged from 3.33 m to 5.52 m. The average nut yield per plant ranged from 0.61 kg to 3.93 kg with highest yield being recorded in H-68 (Table 1.3).

**Table 1.2: Performance of promising hybrids in an un-replicated trial**

Hybrid	Cross combination	Annual yield in 8 <sup>th</sup> harvest (kg/tree)	Cumulative yield for 8 harvests (kg/tree)
H-43	NRCC Sel-2 x Bhuthnath-II	7.3	42.63
H-66	NRCC Sel-2 x Bhuthnath-II	8.0	42.61
H-68	NRCC Sel-2 x Bhuthnath-II	7.5	43.05
H-125	NRCC Sel-2 x Bhedasi	8.5	46.10
H-126	NRCC Sel-2 x Bhedasi	8.0	42.39

**Table 1.3: Performance of promising hybrids in replicated trial**

Hybrid / variety	Plant height (m)	Stem girth (cm)	Canopy spread (m)	Yield (kg/tree) (First harvest)
H-43	3.28	32.33	3.33	1.98
H-66	3.44	36.89	3.86	2.11
H-68	4.04	43.83	5.52	3.93
H-125	3.71	39.39	4.46	2.79
H-126	3.80	37.75	4.06	2.96
H-1250	3.31	31.08	3.80	1.88
H-2452	2.74	26.52	3.37	0.61
H-2473	3.37	34.97	4.04	1.57
NRCC Sel-2 (check)	3.27	32.77	3.91	2.17
Bhaskara (check)	4.51	44.58	4.15	3.35
F-test	*	*	*	*
CD (p=0.05)	0.81	9.41	1.12	1.73

Among the hybrids generated from cross combinations of popular cultivars and dwarf types, the hybrids planted during 2008 exhibited plant height in the range of 1 m to 4.5 m, stem girth in the range of 8 cm to 36 cm and canopy spread in the range of 0.5 m to 4.1 m. While the hybrids planted during 2009 exhibited plant height in the range of 1 m to 5 m, stem girth in the range of 11 cm to 38 cm and canopy spread in the range of 1 m to 4.25 m.

### 1.2.3 Seedling selection in cashew

To find out the variability existing in cashew cultivars raised through seedlings, an experiment was laid out in 2007 by planting the seedling progenies of NRCC Sel-2, Vengurla-4, VRI-3, Bhaskara, VTH-174 and VTH-30/4. Growth parameters with respect to seedling progenies were recorded. Among the seedling progenies of popular cultivars, the plant height, stem girth and yield did not vary among seedling progenies (Table 1.4). However, the canopy spread varied significantly among the seedling progenies. The seedling progenies of NRCC Sel-2 (3.11 m) recorded least spread while, the seedling progenies of VRI-3 recorded highest canopy spread (4.24 m).

### 1.3 DNA extraction

DNA of parents and their F<sub>1</sub> progeny (59 plants) of cross Bhaskara x Taliparamba-1, eight accessions of cashew germplasm and five new hybrids and their parents (3) were isolated following

CTAB buffer extraction procedure. The yield of DNA varied from 122  $\mu\text{gm}^{-1}$  to 1404  $\mu\text{gm}^{-1}$  with 1.5 g of leaf tissue.

### 1.4 Molecular characterization of 45 accessions of cashew

Forty five accessions of cashew germplasm were characterized using RAPD, ISSR and SSR markers. For RAPD 17 random primers, for ISSR 9 selected primers and for SSR 10 primer pairs of cashew were used to generate polymorphic bands. RAPD, ISSR and SSR analysis was carried out individually and together. Based on combined markers, the similarity coefficient values varied from 0.64 to 0.98 with an average diversity of 0.84 indicated low diversity existing among the accessions. However accessions which are highly divergent and which are genetically similar were identified with in the accessions. Similarly, dendrogram based on combined groups could identify 9-10 clusters and in that accessions which are Tsunami resistant, bold nut types and accessions from NEH region (Tripura, Meghalaya and Assam) were found to cluster separately (Fig.1.1) thus markers groupings were in line with the region of their origin and phenotype.

### 1.5 Phenotypic evaluation of F<sub>1</sub> progeny

Phenotypic evaluation of F<sub>1</sub> progeny of Bhaskara x Taliparamba-1 was carried out on morphological, flowering, fruit and yield characters

**Table 1.4: Performance of seedling progenies for growth characters**

Variety	Plant height (m)	Stem girth (cm)	Canopy spread (m)	Yield (kg/plant)
NRCC Sel-2	3.96	34.94	3.11	0.98
V-4	4.25	40.91	3.35	1.45
VRI-3	3.84	44.31	4.24	2.32
Bhaskara	4.69	42.19	3.61	1.68
VTH-174	4.31	41.75	3.53	1.74
VTH-30/4	4.65	40.97	4.02	1.71
CD (p=0.05)	NS	NS	0.56	NS

namely trunk circumference, plant height, lateral spread, no. of primary branches, girth of primary branches, leaf area, no. of leaves / lateral, internodal length, season of flowering, fruits / panicle, fruit weight, nut weight etc. The coefficient of variation varied from 17.6 per cent (plant height) to 29.3 per cent (fruit weight).

### 1.6 Sequencing of markers and SCAR marker development

RAPD markers (OPN 14<sub>775</sub>, UBC 184<sub>475</sub>, UBC 185<sub>275</sub>) identified in germplasm were cloned into pUC T/A cloning vector. Plates were screened and positive clones were sequenced using the facility of M/s. Chromus Biotech Pvt. Ltd., Bengaluru. The

sequences were of 804, 403, 472 and 281 bp in length, respectively. The nucleotide sequence alignment with others in database was done in NCBI site using the BLAST tool. The sequence data was also submitted to Gen Bank and obtained Gen Bank accession numbers. Four set of primers (Forward & Reverse) were designed for the four sequences (markers) using primer 3 plus software and got synthesized at M/s. Chromus Biotech Pvt. Ltd., Bengaluru. SCAR amplification attempted on bulks and individuals of bulks of nut weight and plant stature revealed no polymorphism between the bulks and even between the individuals of bulk thus indicating low reproducibility of markers.

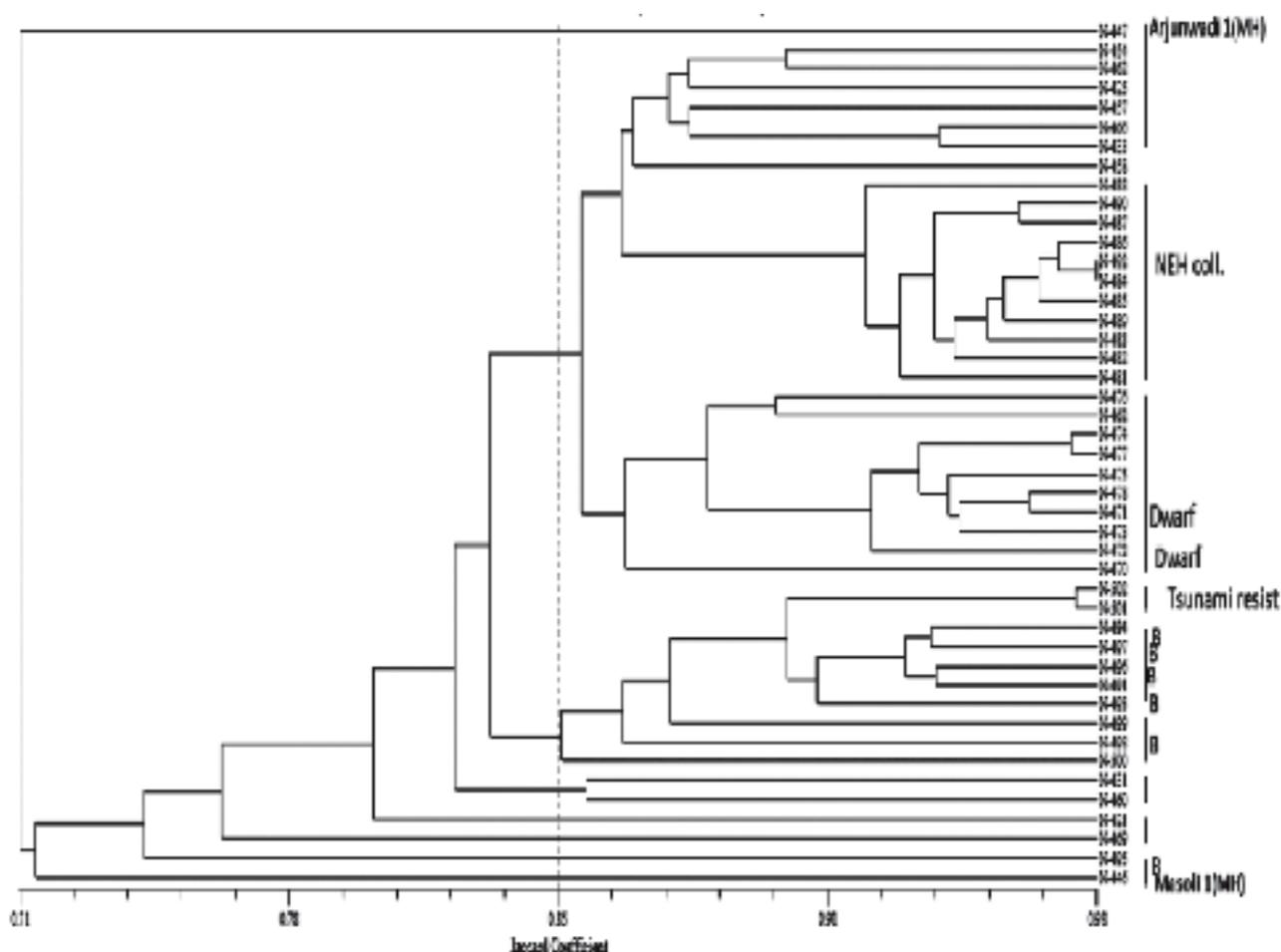


Fig. 1.1: Cluster of 45 accessions of cashew based on combined markers (RAPD+ISSR+SSR)

## 2. CROP MANAGEMENT

### 2.1 Performance of high yielding varieties of cashew in different high density planting system

There is a necessity to find out the optimum density for different varieties of cashew so that the recommendation can go variety wise to achieve highest yield and net profit. Therefore, a field experiment was laid out in 2006 with grafts of nine varieties in four different spacings. The main objectives of the experiment are to determine optimum plant density for achieving the highest yield and profits for the first ten years and to recommend suitable variety for achieving the highest yield and profit for the first ten years under high density planting system.

**Main plot:** Number of trees/ha

S1 - 200 (10 m x 5 m), S2 - 312 (6.5 m x 6.5 m),  
S3 - 384 (6.5 m x 4 m), S4 - 500 (5 m x 4 m)

**Sub plot:** Varieties

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

Design: Split plot, Replication : 3

#### 2.1.1 Observations on growth and yield

After shape pruning, stem girth was more in varieties such as Dhana and Bhaskara (47.7 and 45.3 cm) and lowest in VRI-3 (32.1 cm) (Table 2.1). The varieties like Ullal-3, Bhaskara, NRCC Sel-2, Dhana, Ullal-1 and Madakkathara-2 were taller than other varieties (Table 2.2). Different plant density did not have any significant effect on plant growth except for ground coverage by canopy. Variety Ullal-3 (59.7%) followed by Bhaskara (58.9%) recorded higher ground coverage by the canopy, while, VRI-3 recorded the least coverage by the canopy (36.6%) during 2011 (Table 2.3). With regard to yield per unit area, the highest yield in 2011-12 was recorded in the variety Bhaskara (1178 kg/ha) (Table 2.4). Varieties like Ullal-1, Dhana and Madakkathara-2 performed better than other varieties. Among the different plant densities, density of 500 plants/ha with a mean yield of 1395 kg/ha is the best one. Cumulative yield showed Ullal-3 performed better (2511 kg/ha) followed by Bhaskara (2493 kg/ha) (Table 2.5).

**Table 2.1: Effect of plant density and varieties on the girth (cm) of stem six years after planting**

Varieties Plants/ha	VRI-3	NRCC Sel-2	V-7	Ullal-1	Dhana	Madakka thara-2	Ullal-3	V-4	Bhaskara	Mean
S1-200	30.0	40.8	31.3	41.3	46.3	38.5	45.0	38.3	45.3	39.6
S2-236	32.0	41.8	43.8	42.5	53.0	38.8	41.0	44.8	47.0	42.7
S3-384	35.0	43.0	37.5	40.5	42.5	39.5	45.5	32.5	50.5	40.7
S4-500	31.5	42.5	40.0	41.8	49.0	36.0	40.0	39.5	47.0	40.8
Mean	32.1	42.0	38.2	41.5	47.7	38.2	42.9	38.8	45.3	
CD for main plot (p=0.05)										NS
CD for sub plot (p=0.05)										NS

Main plot = Plant density, Sub plot = Varieties

**Table 2.2: Effect of plant density and varieties on the height of plants (cm)**

Varieties Plants/ha	VRI-3	NRCC Sel-2	V-7	Ullal-1	Dhana	Madakka thara-2	Ullal-3	V-4	Bhaskara	Mean
S1-200	360	438	400	350	450	350	475	475	425	413.7
S2-312	250	469	463	463	438	469	425	450	438	429.4
S3-384	400	438	315	500	475	450	500	375	515	440.9
S4-500	328	410	413	419	369	444	385	355	394	390.8
Mean	334.5	438.8	397.8	433.0	433.0	428.3	446.3	413.8	443.0	
CD for main plot (p=0.05)										NS
CD for sub plot (p=0.05)										50.83

Main plot = Plant density, Sub plot = Varieties

**Table 2.3: Effect of plant density and varieties on the ground coverage by canopy (%)**

Varieties Plants/ha	VRI-3	NRCC Sel-2	V-7	Ullal-1	Dhana	Madakka thara-2	Ullal-3	V-4	Bhaskara	Mean
S1-200	20.0	28.9	31.3	24.2	27.3	21.2	25.8	29.3	22.8	25.6
S2-312	30.3	42.1	49.0	55.7	57.4	45.7	45.2	54.6	59.2	48.8
S3-384	47.2	63.3	54.7	63.1	63.6	49.4	80.5	65.4	73.4	62.3
S4-500	49.0	74.4	78.8	68.2	67.4	63.5	87.1	76.3	80.0	71.6
Mean	36.6	52.2	53.5	52.8	53.9	45.0	59.7	56.4	58.9	
CD for main plot (p=0.05)										10.92
CD for sub plot (p=0.05)										9.62

Main plot = Plant density, Sub plot = Varieties

**Table 2.4: Effect of plant density and varieties on nut yield (kg/ha) (2011-12)**

Varieties Plants/ha	VRI-3	NRCC Sel-2	V-7	Ullal-1	Dhana	Madakka thara-2	Ullal-3	V-4	Bhaskara	Mean
S1-200	610	438	362	744	562	438	592	240	618	511.6
S2-312	688	651	569	844	906	590	621	254	807	658.9
S3-384	860	922	676	891	1121	868	922	422	1398	897.8
S4-500	1305	1545	1276	1600	1550	1785	1000	600	1890	1394.6
Mean	865.8	889.0	720.8	1019.8	1034.8	920.3	783.8	379.0	1178.3	
CD for main plot (p=0.05)										472.98
CD for sub plot (p=0.05)										164.97

Main plot = Plant density, Sub plot = Varieties

**Table 2.5: Effect of plant density and varieties on the cumulative nut yield (kg/ha) (2008-12)**

Varieties Plants/ha	VRI-3	NRCC Sel-2	V-7	Ullal-1	Dhana	Madakka thara-2	Ullal-3	V-4	Bhaskara	Mean
S1-200	985	725	623	1072	875	660	1504	756	1430	959
S2-312	1329	1307	1080	1348	1911	1064	1450	1242	1446	1353
S3-384	2200	3866	2339	2700	3485	2095	2878	1948	3448	2773
S4-500	2238	3304	1908	1841	2267	2392	4213	3037	3648	2761
Mean	1688	2300	1487	1740	2134	1553	2511	1746	2493	
CD for main plot (p=0.05)										1068.8
CD for sub plot (p=0.05)										987.5

Main plot = Plant density, Sub plot = Varieties

### 2.1.2 Soil moisture content under different plant densities

It was found that in treatments of high density planting system, the soil moisture content during January to March was higher than normal density planting system. In the normal density planting system, the soil moisture content was 10.3 to 13.4 per cent dry basis during February whereas in high density planting system it ranged from 10.7 to 18.6 per cent dry basis.

### 2.1.3 Nutrient content of soil and leaf under different plant densities

The soil samples and leaf samples were collected and analyzed for nutrients (0-30 cm and 31-60 cm). The organic carbon content of the soil varied from 0.50 to 0.57 per cent (0-30 cm) (medium) and 0.37 to 0.52 per cent (31-60 cm) (low to medium), the available N content of the soil varied from 74.4 to 81.3 kg ha<sup>-1</sup> (low), the available P<sub>2</sub>O<sub>5</sub> ranged from 19.5 to 25.1 kg ha<sup>-1</sup> (0-30 cm) and 14.1 to 19.7 kg ha<sup>-1</sup> (31-60 cm), the available K<sub>2</sub>O content varied from 108.8 to 168.8 kg ha<sup>-1</sup> (0-30 cm) and 64.6 to 91.1 kg ha<sup>-1</sup> (31-60 cm). A slight increase in the levels of available N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O contents in the soil with high density planting system was found. No significant variation in the content of available micronutrients present in the soil under high density planting system was noted.

The leaf samples were collected and analyzed for nutrients. No significant variation in N, P, K, Ca,

Mg, Cu, Zn, Fe and Mn contents in the leaf with plant density was noted. Nutrient content in the leaf varied with plant variety. Of the selected varieties, the P content was higher in V-4 and V-7 (0.25%) and was lowest in Ullal-1 (0.16%). K content was highest in Dhana (0.57%) and was lowest in Madakkathara-2 (0.40%). Ca content was highest in NRCC Sel-2 (0.45%) and lowest in Dhana (0.21%), Mg content was highest in NRCC Sel-2 (0.25%) and was lowest in VRI-3 (0.16%). Cu content was more in NRCC Sel-2 (13.6 ppm) and lowest in Dhana (9 ppm). Zn content was more in Madakkathara-2 (18 ppm) and was lowest in VRI-3 and V-4 (13 ppm). Fe content was more in NRCC Sel-2 (24.4 ppm) and was lowest in VRI-3 (21.1 ppm). Mn was more in VRI-3 and Dhana (9 ppm) and was lowest in Ullal-1 (7 ppm).

## 2.2 Irrigation requirement of cashew under high density planting system

In India, cashew is generally grown as a rainfed crop on neglected land unsuitable for any other crop. Cashew experiences severe moisture stress from January to May, adversely affects its flowering and fruit set. In order to harvest the rainwater and to make it available to the cashew plant during critical period, an *in situ* soil and water conservation and rainwater harvesting are very important. Previous trials conducted showed that cashew yield can be substantially increased by critical irrigation or drip irrigation during its fruit set. Irrigation should not be given before or at the time of flowering, as it is likely to promote vegetative

growth. Based on earlier research work, by adopting high density planting system in cashew (500 plants/ha), the yield of cashew can be increased by 2.2 times of the normal density planting system (156 plants/ha with a yield of 1.2  $\text{tha}^{-1}$ ) for the first ten years. Hence, there is possibility of increased production by planting cashew grafts under high density planting system and also by proper water and nutrient management. Therefore, optimal irrigation requirement of cashew under different plant densities would be standardized in this study.

Field experiment was laid out with three different spacings [5 m x 4 m (500 plants/ha), 6 m x 4 m (416 plants/ha), 10 m x 5 m (200 plants/ha)] with cashew variety Bhaskara in 2011. Design : Split plot, Replication : 3.

Main plot treatments: Plant density

- M1: 5 m x 4 m (500 plants/ha)
- M2: 6 m x 4 m (416 plants/ha)
- M3: 10 m x 5 m (200 plants/ha)

Sub plot treatments: Irrigation levels

- T1: 20% CPE
- T2: 40% CPE
- T3: 60% CPE
- T4: optimal irrigation using rainwater harvesting
- T5: critical irrigation (once in 15 days) using rainwater harvesting
- T6: Soil and water conservation technique
- T7: Control (without irrigation and soil & water conservation)

The initial soil samples were collected and analyzed for nutrients. The soil was acidic (pH 4.8 to 5.3) and EC of soil ranged from 0.030  $\text{dS m}^{-1}$  (0-30 cm) to 0.012  $\text{dS m}^{-1}$  (31-60 and 61-90 cm). Low in available N, available  $\text{P}_2\text{O}_5$  and medium in available  $\text{K}_2\text{O}$  content. The major nutrients showed a decreasing trend with increase in depth of the soil. The soil moisture content at three different depths during January to March, 2012 was recorded using TDR soil moisture profiling system. The soil moisture

content during February was 11.0 to 12.7 per cent dry basis whereas in March, it was 10.2 to 11.2 per cent dry basis i.e., below the available soil moisture range. The growth data was collected and no significant difference in growth of cashew plants was observed.

## 2.3 Effect of foliar application of nutrients on cashew

### 2.3.1 Effect of foliar spray of nutrients on leaf nutrient concentration, yield attributes and quality of cashew kernel

A field experiment was initiated in 2009 to investigate the effect of foliar application of major nutrients and, secondary and micronutrients on nine year old cashew trees (NRCC Sel-2). Foliar spray of major nutrients on cashew at three different stages viz., flushing, flowering and nut development significantly increased the leaf nutrient concentration, number of bisexual flowers, number of panicles and number of nuts per tree compared to untreated plants.

#### Experiment I: Foliar spray of major nutrients on cashew

1. Urea 3%
2. Orthophosphoric acid ( $\text{H}_3\text{PO}_4$ ) 0.5%
3.  $\text{K}_2\text{SO}_4$  1%
4. Urea 3% +  $\text{H}_3\text{PO}_4$  0.5%
5. Urea 3% +  $\text{K}_2\text{SO}_4$  1%
6.  $\text{H}_3\text{PO}_4$  0.5% +  $\text{K}_2\text{SO}_4$  1%
7. Urea 3% +  $\text{H}_3\text{PO}_4$  0.5% +  $\text{K}_2\text{SO}_4$  1%
8. Control

#### Experiment II: Foliar spray of secondary and micronutrients on cashew

1.  $\text{ZnSO}_4$  0.5%
2. Solubor 0.1%
3.  $\text{MgSO}_4$  0.5%
4.  $\text{ZnSO}_4$  0.5% + Solubor 0.1%
5.  $\text{ZnSO}_4$  0.5% +  $\text{MgSO}_4$  0.5%
6. Solubor 0.1% +  $\text{MgSO}_4$  0.5%
7.  $\text{ZnSO}_4$  0.5% + Solubor 0.1% +  $\text{MgSO}_4$  0.5%
8. Control

The nutrient content of the index leaves (4<sup>th</sup> and 5<sup>th</sup> matured leaves) sampled after foliar nutrition treatments were appreciably higher in foliar spray treated plants as compared to the untreated plants (Table 2.6 and 2.7). The N content ranged from 1.50 to 2.01 per cent (Experiment I) and 1.56 to 1.95 per cent (Experiment II), P: 0.14 to 0.31 per cent (Experiment I) and 0.15 to 0.22 per cent (Experiment II), K: 0.63 to 0.90 per cent (Experiment I) and 0.70 to 0.81 per cent (Experiment II), Fe: 28.3 to 38.5 ppm (Experiment I) and 36.5 to 46.9 ppm (Experiment II), Mn: 19.8 to 26.3 ppm (Experiment I) and 20.1 to 28.9 ppm (Experiment II), Zn: 11.8 to 18.4 ppm (Experiment I) and 16.6 to 22.6 ppm (Experiment II), and Cu: 8.8 to 14.1 ppm (Experiment I) and 8.9 to 14.4 ppm (Experiment II). No significant difference was observed in leaf surface area and stomatal

openings with respect to foliar spray of nutrients. Of the major nutrients, 3% urea + 0.5% H<sub>3</sub>PO<sub>4</sub> + 1% K<sub>2</sub>SO<sub>4</sub> recorded the highest number of bisexual flowers (20.1%), number of panicles (220), number of nuts (198) and nut yield/tree (1.84 kg) (Fig. 2.1 and Table 2.8). In case of secondary and micronutrients, 0.5% ZnSO<sub>4</sub> + 0.1% solubor + 0.5% MgSO<sub>4</sub> treated plants showed the highest number of bisexual flowers (22.9%), number of panicles (284), number of nuts (220) and nut yield/tree (2.05 kg) and (Fig. 2.2 and Table 2.9). Defatted cashew kernel was analysed for protein, sugars and starch. There was no significant difference in the protein (35.91 to 40.39 per cent), starch (36.6 to 41.8 mg/100 g) and sugar (9.55 to 10.22 mg/100 g) content of the defatted kernel of cashew among the foliar sprayed and untreated plants.

**Table 2.6: Leaf nutrient content as affected by foliar spray of major nutrients (Experiment I)**

Treatment	N (%)	P (%)	K (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)
Urea (3%)	2.00	0.21	0.72	28.3	20.9	18.4	9.9
H <sub>3</sub> PO <sub>4</sub> (0.5%)	1.84	0.28	0.65	32.6	23.5	17.9	12.2
K <sub>2</sub> SO <sub>4</sub> (1%)	1.50	0.17	0.90	30.5	24.7	16.8	13.1
Urea + H <sub>3</sub> PO <sub>4</sub>	2.01	0.25	0.78	38.5	26.3	18.2	14.1
Urea + K <sub>2</sub> SO <sub>4</sub>	1.95	0.14	0.88	35.0	25.4	18.0	13.0
H <sub>3</sub> PO <sub>4</sub> + K <sub>2</sub> SO <sub>4</sub>	1.68	0.31	0.82	34.8	23.0	17.5	13.5
Urea + H <sub>3</sub> PO <sub>4</sub> + K <sub>2</sub> SO <sub>4</sub>	1.97	0.29	0.90	37.6	26.2	17.5	14.0
Control	1.52	0.15	0.63	31.0	19.8	11.8	8.8

**Table 2.7: Leaf nutrient content as affected by foliar spray of secondary and micronutrients (Experiment II)**

Treatment	N (%)	P (%)	K (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)
ZnSO <sub>4</sub> (0.5%)	1.84	0.18	0.80	44.1	23.2	22.3	11.0
Solubor (0.1%)	1.82	0.20	0.78	40.3	21.6	19.2	10.8
MgSO <sub>4</sub> (0.5%)	1.78	0.22	0.75	38.5	24.1	20.0	12.1
ZnSO <sub>4</sub> + Solubor	1.80	0.19	0.81	46.9	28.2	21.9	14.4
ZnSO <sub>4</sub> + MgSO <sub>4</sub>	1.90	0.17	0.77	42.3	28.9	22.6	12.8
Solubor + MgSO <sub>4</sub>	1.78	0.21	0.75	41.6	25.8	19.6	14.0
ZnSO <sub>4</sub> + MgSO <sub>4</sub> + Solubor	1.95	0.18	0.78	46.0	28.0	22.0	13.6
Control	1.56	0.15	0.70	36.5	20.1	16.6	8.9

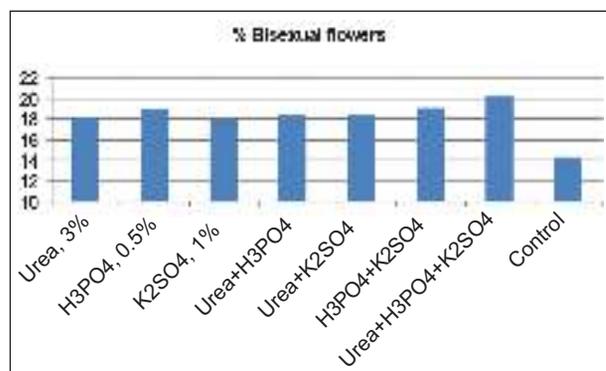


Fig. 2.1: Effect of foliar spray of major nutrients on bisexual flowers

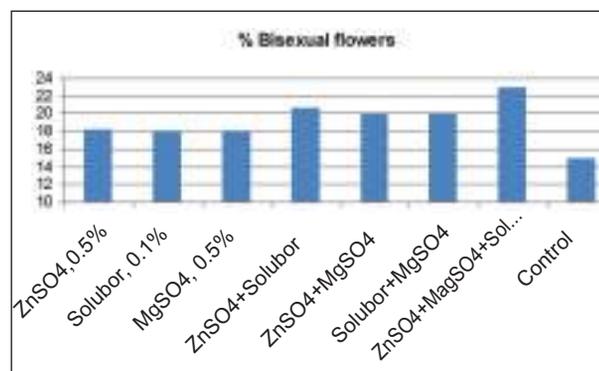


Fig. 2.2: Effect of foliar spray of secondary and micronutrients on bisexual flowers

Table 2.8: Yield attributes of cashew as affected by foliar spray of major nutrients

Treatment	No. of panicles/tree	No. of nuts/tree	Nut yield (kg/tree)	Cumulative nut yield (kg/tree) (3 harvests)
Urea (3%)	198	177	1.62	4.48
H <sub>3</sub> PO <sub>4</sub> (0.5%)	192	180	1.66	4.62
K <sub>2</sub> SO <sub>4</sub> (1%)	190	176	1.61	4.42
Urea + H <sub>3</sub> PO <sub>4</sub>	201	180	1.67	4.68
Urea + K <sub>2</sub> SO <sub>4</sub>	200	185	1.71	4.53
H <sub>3</sub> PO <sub>4</sub> + K <sub>2</sub> SO <sub>4</sub>	208	191	1.77	4.86
Urea + H <sub>3</sub> PO <sub>4</sub> + K <sub>2</sub> SO <sub>4</sub>	220	198	1.84	4.89
Control	174	160	1.46	4.14

Table 2.9: Yield attributes of cashew as affected by foliar spray of secondary and micronutrients

Treatment	No. of panicles/tree	No. of nuts/tree	Nut yield (kg/tree)	Cumulative nut yield (kg/tree) (3 harvests)
ZnSO <sub>4</sub> (0.5%)	220	198	1.81	4.76
Solubor (0.1%)	259	200	1.80	4.95
MgSO <sub>4</sub> (0.5%)	245	195	1.76	4.75
ZnSO <sub>4</sub> + Solubor	280	216	1.95	5.41
ZnSO <sub>4</sub> + MgSO <sub>4</sub>	275	216	1.97	5.27
Solubor + MgSO <sub>4</sub>	264	210	1.91	4.94
ZnSO <sub>4</sub> + MgSO <sub>4</sub> + Solubor	284	220	2.05	5.53
Control	189	179	1.63	4.04

### 2.3.2 Effect of foliar spray of nutrients on soil nutrient status

Soil samples were collected at 0-0.30 m (surface soil) and 0.31-0.60 m (subsurface soil) depths from base of the plant at 1.5 m radius after foliar nutrition treatments. The soil nutrient levels

were relatively higher in foliar sprayed plots as compared to control plots. The soil pH varied from 5.72 to 6.09 (Experiment I) and 5.90 to 6.14 (Experiment II), EC 0.020 to 0.035 dS m<sup>-1</sup> (Experiment I) and 0.024 to 0.038 dS m<sup>-1</sup> (Experiment II), organic carbon 7.6 to 8.5 g kg<sup>-1</sup>

(Experiment I) and 8.6 to 9.24 g kg<sup>-1</sup> (Experiment II), exchangeable Mg 0.47 to 0.82 cmol(p<sup>+</sup>)kg<sup>-1</sup> and 0.53 to 0.78 cmol(p<sup>+</sup>)kg<sup>-1</sup>, available N 144.8 to 192.5 kg ha<sup>-1</sup> (Experiment I) and 170.5 to 217.2 kg ha<sup>-1</sup> (Experiment II), available P 18.8 to 22.8 kg ha<sup>-1</sup> (Experiment I) and 14.0 to 18.6 kg ha<sup>-1</sup> (Experiment II), available K 118.5 to 150.8 kg ha<sup>-1</sup> (Experiment I) and 125.0 to 158.3 kg ha<sup>-1</sup> (Experiment II). Except Zn and B, other micronutrient levels in soil were in adequate amount. The available Fe varied from 36.0 to 42.5 mg kg<sup>-1</sup> (Experiment I) and 35.1 to 43.1 mg kg<sup>-1</sup> (Experiment II), available Mn 22.5 to 31.0 mg kg<sup>-1</sup> (Experiment I) and 25.1 to 33.5 mg kg<sup>-1</sup> (Experiment II), available Zn 0.18 to 0.39 mg kg<sup>-1</sup> (Experiment I) and 0.29 to 0.37 mg kg<sup>-1</sup> (Experiment II), available Cu 0.66 to 0.78 mg kg<sup>-1</sup> (Experiment I) and 0.60 to 0.75 mg kg<sup>-1</sup> (Experiment II), and available B 0.18 to 0.29 mgkg<sup>-1</sup> (Experiment I) and 0.15 to 0.39 mgkg<sup>-1</sup> (Experiment II).

## 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) and mature (Nine years old cashew variety Bhaskara) 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)
  - i. Control (No inoculation)
  - ii. Biofertilizer (*Azospirillum*, *Acetobacter*, Phosphate solubilizing bacteria and AMF 50 g each/tree) inoculation around tree basin to a radius of 45 cm
  - iii. Biofertilizer (*Azospirillum*, *Acetobacter*, Phosphate solubilizing bacteria and AMF 50 g each/tree) inoculation in the

rectangular trenches taken in the middle of four trees

- iv. Combination of ii + iii
- (b) Sub plot treatments (Fertilizer levels)
  - i. Control (No application)
  - ii. 50% of recommended NPK through drip + FYM
  - iii. 75% of recommended NPK through drip + FYM
  - iv. \*100% of recommended NPK through drip + FYM
  - v. Soil test based fertiliser recommendation through drip

\* 100% of recommended dose: N 135 g : P<sub>2</sub>O<sub>5</sub> 39 g : K<sub>2</sub>O 34 g and FYM 5.6 kg per tree per annum.

### 2.4.1 Effect of INM strategies on soil physico-chemical properties

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 pH, EC, organic carbon, cation exchange capacity (CEC), soil texture and available nutrients. The nutrient content of the soil varied significantly under different treatments. Soil pH varied from 5.4 to 5.98, EC 0.039 to 0.051 dS m<sup>-1</sup>, organic carbon content 1.0 to 1.23 per cent, CEC 7.36 to 19.70 cmol(p<sup>+</sup>)kg<sup>-1</sup>, texture of the soils varied from sandy clay loam to sandy loam, exch. Ca 0.87 to 1.22 cmol(p<sup>+</sup>)kg<sup>-1</sup> and exch. Mg 0.60 to 0.89 cmol(p<sup>+</sup>)kg<sup>-1</sup> in different treatments. Available N, P and K contents in the soils ranged from 271.2 to 352.3 kg ha<sup>-1</sup>, 16.1 to 24.2 kg ha<sup>-1</sup> and 140.1 to 198.25 kg ha<sup>-1</sup>, respectively. DTPA extractable (Available) Fe, Mn, Zn and Cu contents varied from 82.5 to 146.45 mg kg<sup>-1</sup>, 8.0 to 15.0 mg kg<sup>-1</sup>, 0.31 to 0.75 mg kg<sup>-1</sup> and 0.62 to 1.02 mg kg<sup>-1</sup>, respectively. Application of biofertilizer consortia [*Azospirillum*, *Acetobacter*, Phosphate solubilizing bacteria and AMF inoculation both to the tree basin at a radius of 45 cm (50 g each/tree) and in the rectangular trenches taken in the middle of four trees (50 g each/tree)] and 100% of recommended dose of nutrients (N: 135

g, P<sub>2</sub>O<sub>5</sub>: 39 g, K<sub>2</sub>O: 34 g and FYM: 5.6 kg per tree per annum) had resulted in better soil health.

#### 2.4.2 Effect of INM strategies on nutrient content of index leaf, growth, yield attributes and quality of kernel

Leaf nutrient concentrations were consistently affected by the INM treatments. The treatments 100% of recommended NPK through drip + FYM and soil test based fertiliser recommendation through drip + FYM resulted in higher nutrient concentrations as compared to other treatments. The nutrient concentration of the index leaf in different treatments varied from N: 1.35 to 1.98 per cent, P: 0.10 to 0.22 per cent, K: 0.60 to 0.88 per cent, Fe: 31.5 to 42.3 ppm, Mn: 24.0 to 32.6 ppm, Zn: 16.1 to 26.8 ppm and Cu: 11.5 to 15.5 ppm.

Application of biofertilizer consortia (*Azospirillum*, *Acetobacter*, Phosphate solubilizing bacteria and AMF) inoculation both to the tree basin at a radius of 45 cm (50 g each/tree) and in the rectangular trenches taken in the middle of four trees (50 g each/tree) along with 100% NPK+FYM resulted in higher growth, number of panicles and nuts per tree in young cashew plantation. Neither method of biofertilizer application nor fertilizer levels affected growth parameters of mature cashew plantation. The average plant height in different treatments ranged from 385 to 440 cm (young cashew plantation) and 760 to 920 cm (mature cashew plantation). The trunk girth ranged from 37.0 to 43.0 cm (young cashew plantation) and 66.0 to 81.1 cm (mature cashew plantation). The canopy spread

ranged from 440 to 480 cm (young cashew plantation) and 725 to 820 cm (mature cashew plantation) (Tables 2.10 and 2.11). Application of biofertilizer consortia both to the tree basin at a radius of 45 cm and in the rectangular trenches taken in the middle of four trees along with 100% NPK+FYM resulted in maximum nut yield (2.52 and 10.52, kg/tree in young cashew and mature cashew plantation, respectively) and cumulative yield (three harvests) (5.95 and 29.18 kg/tree in young cashew and mature cashew plantation, respectively) (Tables 2.12 and 2.13).

Method of biofertilizer application and fertilizer levels did not produce any significant difference in the quality of cashew kernel. The protein, starch and sugar content of the defatted cashew kernel ranged from 34.58 to 41.2 per cent, 36.0 to 42.9 mg/100 g and 8.85 to 10.04 mg/100 g, respectively. The INM treatments resulted in slightly higher content of inorganic constituents in cashew kernel as compared to untreated plants. Cashew kernel contained 5.53 to 6.59 per cent N, 0.51 to 0.63 per cent P, 0.37 to 0.46 per cent K, 0.032 to 0.040 per cent Ca and 0.18 to 0.25 per cent Mg under different treatments.

#### 2.5 Rootstock studies in cashew

The different stionic combinations planted in the field were compared for various growth parameters and yield. The various stionic combinations varied with respect to growth parameters. Among different stionic combinations, number of leaves, leaf area, stomatal count and yield

**Table 2.10: Integrated nutrient management treatment effects on growth of cashew variety VRI-3 (young cashew plantation) (3<sup>rd</sup> year experiment)**

Treatment	Plant height (cm)					Girth (cm)					Canopy spread (cm)				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
M1	385	385	390	396	390	37.0	37.9	39.0	38.5	37.2	440	440	442	445	440
M2	392	394	390	425	427	37.0	37.8	38.7	39.1	41.0	440	441	440	452	448
M3	393	402	398	410	399	37.2	38.0	39.0	36.9	38.9	442	440	447	464	453
M4	404	407	418	440	420	39.5	41.6	41.0	43.0	43.0	445	450	451	480	474

**Table 2.11: Integrated nutrient management treatment effects on growth of cashew variety Bhaskara (mature cashew plantation) (3<sup>rd</sup> year experiment)**

Treatment	Plant height (cm)					Girth (cm)					Canopy spread (cm)				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
M1	851	825	829	793	835	72.5	70.3	70.8	77.3	74.0	727	725	800	760	804
M2	825	790	778	798	808	72.0	76.0	71.5	72.5	81.1	755	730	790	820	790
M3	853	760	920	819	885	67.9	69.5	69.5	67.0	71.6	725	732	750	820	740
M4	805	832	846	826	910	71.6	73.2	68.4	74.2	72.0	730	810	770	730	750

**Table 2.12: Integrated nutrient management treatment effects on nut yield of young cashew plantation (VRI-3)**

Treatment	Yield (kg/tree)					Cumulative nut yield (three harvests) (kg/tree)				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
M1	1.7	1.89	2.16	1.94	1.90	3.95	4.22	4.75	4.97	4.79
M2	1.98	2.2	2.48	2.25	2.31	4.32	4.55	5.30	5.47	5.42
M3	1.78	1.95	2.28	2.30	2.20	4.49	4.69	5.47	5.31	5.24
M4	2.1	2.39	2.50	2.52	2.45	4.8	5.24	5.80	5.95	5.59

**Table 2.13: Integrated nutrient management treatment effects on nut yield of mature cashew plantation (Bhaskara)**

Treatment	Yield (kg/tree)					Cumulative nut yield (three harvests) (kg/tree)				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
M1	7.95	8	8.8	9.3	8.92	23.08	22.88	24.34	26.06	24.85
M2	8.6	8.72	9.2	9.75	9.45	24.24	24.35	25.98	26.99	25.99
M3	8.2	8.3	9.21	9.65	9.23	22.8	23.49	25.3	27.51	25.63
M4	9.1	9.1	10.35	10.52	10.21	25.43	25.57	28.29	29.18	27.61

per plant varied significantly among stionic combinations. Leaf area was least in V-4 grafted on Taliparamba-1 rootstock while it was highest in Ullal-3 grafted on V-4 rootstock. The stomatal count in leaves increased whenever dwarf types were used as rootstocks. The plant from a stionic combination of Ullal-3 grafted on Brazil dwarf rootstock recorded the highest yield of 3.20 kg/plant (Table 2.14).

## 2.6 Effect of paclobutrazol on growth and yield of cashew

Paclobutrazol (PBZ) was applied to the plants @ 1 g, 2 g and 3 g a.i. per plant. The observations on growth parameters have been

recorded after the application of paclobutrazol. The plant height among PBZ treated plants ranged from 218.75 cm to 230.75 cm, while the untreated plants recorded the height 241.55 cm. The girth at collar region among PBZ treated plants ranged from 24.35 cm to 25.78 cm, while the untreated plants recorded an average girth of 28.22 cm. The canopy spread in E-W direction among PBZ treated plants ranged from 189.00 cm to 209.42 cm, while the untreated plants recorded an average spread of 208.97 cm in the same direction. The canopy spread in N-S direction among PBZ treated plants ranged from 198.75 cm to 211.17 cm, while the untreated plants recorded an average spread of 217.73 cm in the same direction. The

**Table 2.14: 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)	Canopy spread (m)	Leaf area (cm <sup>2</sup> )	Internodal length (cm)	Stomatal count	Yield kg/plant
Ullal-3/ V-4	3.39	8.28	35.20	29.90	3.73	135.13	1.20	52	0.78
VRI-3/V-4	3.02	10.79	30.32	26.41	2.66	102.26	1.57	52	1.83
NRCC Sel-2/V-4	3.29	9.83	31.11	27.88	3.57	90.72	1.32	55	0.52
V-4/V-4	3.42	9.17	34.04	30.64	3.33	102.84	1.23	63	1.72
Ullal-3/ Brazil dwarf	3.88	8.80	37.95	33.18	3.53	125.03	1.67	49	2.92
VRI-3/ Brazil dwarf	3.53	10.33	34.13	29.99	3.83	84.55	1.35	63	3.20
NRCC Sel-2/ Brazil dwarf	3.23	9.16	32.40	28.16	3.36	93.04	1.32	65	1.80
V-4/ Brazil dwarf	3.20	9.05	30.12	26.55	3.00	82.15	1.34	67	1.68
Ullal-3/ Taliparamba-1	3.68	7.99	36.12	28.58	3.34	102.56	1.52	62	1.65
VRI-3/ Taliparamba-1	2.53	10.49	26.09	21.97	2.16	101.39	1.51	66	1.12
NRCC Sel-2/ Taliparamba-1	2.87	10.50	26.75	23.62	2.49	82.58	1.52	74	0.3
V-4/ Taliparamba-1	2.50	10.00	34.66	27.0	3.12	77.17	1.48	74	0.3
CD at 5%	NS	1.39	NS	NS	NS	29.76	NS	8.61	1.39

number of new flushes among PBZ treated plants ranged between 106.10 to 145.00, while the untreated plants produced 146.56 new flushes. The internodal length of PBZ treated plants ranged between 5.93

mm to 11.94 mm, while the untreated plants recorded an average internodal length of 24.97 cm indicating the role of PBZ in reducing the plant vigour (Table 2.15).

**Table 2.15: Effect of paclobutrazol on morphometric parameters of variety Ullal-3**

Treatment	Plant height (cm)	Girth (cm)	Canopy spread (E-W)	Canopy spread (N-S)	No. of flushes	Internodal length (mm)
Control	241.55	28.22	208.97	217.73	146.56	24.97
PBZ @ 1 g a.i./plant	230.75	24.35	205.25	202.50	145.00	11.94
PBZ @ 2 g a.i./plant	218.75	24.98	189.00	198.75	106.10	7.24
PBZ @ 3 g a.i./plant	223.83	25.78	209.42	211.17	109.92	5.93

## 2.7 Organic farming in cashew

A field experiment on organic farming in cashew has been initiated in Block No 8, orchard management plot of Kemminje campus by planting cashew grafts in pits of 1 m x 1 m x 1 m size and at a spacing of 7.5 m x 7.5 m (Normal spacing). The treatment details are given below:

1. FYM to supply 500 g N/tree
2. FYM to supply 500 g N/tree+ biofertilizer consortia\*
3. FYM to supply 500 g N/tree + Rock phosphate

to supply 125 g P<sub>2</sub>O<sub>5</sub>/tree and woodash to supply 125 g K<sub>2</sub>O/tree.

4. Poultry manure to supply 500 g N/tree
5. *In situ* composting using recyclable cashew biomass and weeds
6. *In situ* composting using recyclable cashew biomass and weeds + green manuring (Growing glyricidia between two rows of cashew)
7. Vermicomposting of recyclable cashew biomass

8. FYM + Organic cakes + Recyclable cashew biomass + biofertilizer consortia
9. Recommended NPK fertilizer\*\*
10. Recommended NPK fertilizer + 10 kg FYM/tree
11. Control.

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

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

### 2.7.1 Nutrient status of initial soil

Initial soil samples at three different depths (0-30, 31-60 and 61-90 cm) were collected and have been characterized for pH, electrical conductivity, organic carbon and available N, P, K and micronutrients *viz.*, Fe, Mn, Zn and Cu (Table 2.16). The soils were acidic in reaction, free of soluble

salts (non saline in nature), high in organic carbon in the surface soil and decreased with increasing soil depth.

The soils were low in available nitrogen, medium to high in available phosphorus and medium to high in available potassium. Surface soils were found to contain more amounts of available N, P and K than subsurface soils. The reason for higher amount of nutrients in surface soil might possibly be due to the confinement of crop cultivation to the rhizosphere and supplementing of the depleted nutrients through external sources *i.e.*, fertilizers. This could also be attributed to the addition of plant residues and farmyard manure to surface soil than in the lower horizons. Available Fe, Mn, Zn and Cu varied from 15.29 to 21.31 mg kg<sup>-1</sup>, 3.41 to 6.45 mg kg<sup>-1</sup>, 0.90 to 1.39 mg kg<sup>-1</sup> and 0.61 to 0.90 mg kg<sup>-1</sup> at different soil depths. A consistent decrease in the contents of available micronutrients with the increase in soil depth was noted. Considering 4.5 mg DTPA-Fe kg<sup>-1</sup> soil, 2 mg DTPA-Mn kg<sup>-1</sup> soil, 0.6 mg DTPA-Zn kg<sup>-1</sup> soil, and 0.20 mg DTPA-Cu kg<sup>-1</sup> soil as critical limits, the soils were found to be sufficient in available Fe, Mn, Zn and Cu.

**Table 2.16: Initial properties of the experimental soil**

Soil property	Soil depth (cm)		
	0-30	31-60	61-90
pH	5.58	5.46	5.44
EC (d Sm <sup>-1</sup> )	0.036	0.021	0.017
Organic carbon (g kg <sup>-1</sup> )	13.9	12.8	11.5
Available N (kg ha <sup>-1</sup> )	245	205	195
Available P (kg ha <sup>-1</sup> )	47.1	36.6	21.9
Available K (kg ha <sup>-1</sup> )	303	168	110
Available Fe (mg kg <sup>-1</sup> )	21.31	18.50	15.29
Available Mn (mg kg <sup>-1</sup> )	6.45	4.35	3.41
Available Zn (mg kg <sup>-1</sup> )	0.90	0.75	0.61
Available Cu (mg kg <sup>-1</sup> )	1.39	1.05	0.90

### 3. CROP PROTECTION

#### 3.1 Cashew Stem and Root Borers (CSRB)

##### 3.1.1 Working out LT<sub>50</sub> of various EPN species

The virulence of entomopathogenic nematodes (EPN), *Heterorhabditis indica*, *Steinernema abbasi* and *Steinernema bicornutum* (Rhabditida : Heterorhabditidae, Steiner-nematidae) against grubs of cashew stem and root borers (*Plocaederus spp.*) and *Batocera rufomaculata* (Coleoptera: Cerambycidae) was studied under laboratory conditions. The grubs of CSRB were allowed to crawl for 12 h in soil treated with the Infective Juvenile suspension (IJs). All three species of EPN induced mortality of *Plocaederus* grubs in a mean duration of 14.11, 12.88 and 12.37 days, respectively.

*Heterorhabditis indica* induced mortality within a mean duration of 7.42 days, in grubs of *Batocera rufomaculata* which was superior to duration of mean mortality (18.25 days) induced by *Steinernema abbasi* and by *Steinernema bicornutum* (17.94 days). It was noticed that, the body weight was strongly correlated to emergence of IJs from infected cadavers of the CSRB grubs in all the three spp. of EPN (Table 3.1)

##### 3.1.2 Determination of persistence of the EPN species in soil under simulated conditions

The survival ability of the promising strains

of EPN under simulated conditions was studied. 100 ml of IJs suspension was added to 5 kg of autoclaved soil placed in earthen pots and samples were collected from these pots at intervals viz., 5, 10, 15, 30, 60, 90, 120 and 150 days. Well grown wax moth larvae were used as bait insect which were allowed to crawl in these soil samples for 6 h and the mortality was recorded. It was noticed that the mean mortality levels reduced considerably beyond 15 days after treatment (DAT) in case of all species of EPN. The mean percentage mortality of wax moth larvae used as bait was 100 per cent up to 10 DAT, while it was more than 50 per cent up to 15 DAT. Both the species of *Steinernema* induced more than 50 per cent mean mortality of bait insect upto 60 DAT while, the mean mortality in case of *Heterorhabditis indica* was 19.33 per cent on 60 DAT. It was observed that *Steinernema bicornutum* induced more than 50 per cent mean mortality of the bait species even after 150 DAT.

*Heterorhabditis indica* and *Steinernema abbasi* could survive beyond 90 DAT, but the numbers of virulent IJs to reduced drastically beyond 30 DAT as indicated by the low level of mean mortality induced in the bait insect larvae. The mean percentage mortality of larvae of wax moth at 150 DAT was 8.33 in case of *H. indica* and 9.33 in case of *S. abbasi*, which was significantly lower in comparison to the mean

**Table 3.1: Mean duration for mortality induction in CSRB grubs by different species of EPN**

EPN Species	Mean duration (in days) for mortality in case of			
	<i>Plocaederus</i> spp. (Lab. reared grubs)	<i>Plocaederus</i> spp. (Field collected grubs)	<i>Batocera rufomaculata</i> (Field collected grubs)	Untreated control
<i>Heterorhabditis indica</i>	5.25 a (4-6)	14.11 bc (8-17)	7.42 a (4-10)	0.00 d
<i>Steinernema abbasi</i>	5.75 a (5-8)	12.88 b (11-27)	18.25 c (13-19)	0.00 d
<i>Steinernema bicornutum</i>	5.45 a (3-8)	12.37 b (9-19)	17.94 c (15-23)	0.00 d
	Main group CD (p= 0.01) = 3.44		Sub group CD (p=0.01) = 3.56	

Figures in the parentheses indicate range in the duration of mortality

percentage mortality of wax moth larvae induced by *S. bicornutum* (57.92). The mean percentage mortality of wax moth larvae was insignificant beyond 150 DAT (Table 3.2).

### 3.1.3 Constituent analysis of volatiles 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 CPCRI, Kasaragod. 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, tri methyl tetradecane, fluoro methyl carboxylic acid, 6-methyl octodecane, hexanoic acid and dodecanoic acid; were identified from frass volatiles and the elution time ranged from 5.4 to 12.1 seconds for different compounds. The compounds identified from fresh bark were trans-2-hexanol, nonane, trifluoro-acetoxy pentadecane, trifluoro-acetoxy dodecane and dodecanoic acid which had an elution time of 5.6 to 12.2 seconds. Both the samples had certain common compounds which need to be quantified.

## 3.2 Evaluation of causes for black spot formation in cashew kernels

### 3.2.1 Assessment of intensity of black spot formation on cashew kernels

The intensity of black spot on cashew kernels collected from various months of the cropping season (November to April) did not show any significant differences among the samples. The intensity of black spot varied from 3.24 to 5.66 per cent in kernels obtained from caged and uncaged panicles which were on par with each other.

### 3.2.2 Identification of possible association of any pathogens to be isolated from the black spot region on the kernels

The processed cashew kernel samples were taken for identification of fungal mycelia or fungal damage symptoms at IISR, Kozhikode. Few strands of mycelia were noticed in the black spot regions however, these could not be cultured as the viability of fungal mycelia or spores would have been lost due to the high temperature adopted during the steam roasting process. Hence, the possible occurrence of black spot symptoms in initial stages in the field conditions was studied. The occurrence of black spot in field condition was very negligible (<1.5%), but occurrence could be noticed in tender / green nuts, indicating that the reason for black spot development was not due to storage or processing parameters, but possibly due to fungal infection which needs further confirmation.

**Table 3.2: Persistence of different EPN species in soil under simulated conditions**

EPN Species	Mean % mortality of test insect after							
	5 DAT	10 DAT	15 DAT	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT
<i>Heterorhabditis indica</i>	100 a	100 a	55.16 ef	33.32 g	19.33 h	11.00 i	10.00 i	8.33 i
<i>Steinernema abbasi</i>	100 a	100 a	89.26 b	67.78 d	50.00 f	32.22 g	26.51 g	9.33 i
<i>Steinernema bicornutum</i>	100 a	100 a	100 a	83.97 bc	80.00 c	78.89 c	62.72 de	57.92 ef
Untreated control	*	*	*	*	*	*	*	*

DAT = Days after treatment

### 3.3. Studies on insect fauna associated with stored cashewnuts

#### 3.3.1 Determination of odour staining of treated kernels

The odour staining due to treatment of cashew kernels using food grade repellants 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 methyl benzoxide and in case of vanillin. However, the odour was not recognisable and was judged as “kernels without odour” by all the organoleptic evaluators at the lowest dose of 0.025 per cent (Table 3.3).

### 3.4 Tea Mosquito Bug (TMB)

#### 3.4.1 Biosystematics of TMB

*Helopeltis antonii*, *H. bradyi*, *H. theivora* and *Pachypeltis maesarum* were collected from different geographical locations in India on different

host plants for molecular diversity studies. Mitochondrial cytochrome oxidase-1 (COX-1) was successfully sequenced from 32 individuals. A total fragment size of 658 bp of the Mitochondrial cytochrome oxidase-1 (COX-1) was analyzed for all 32 individuals of tea mosquito bug. All the sequences obtained were deposited in NCBI-Gen Bank with accession numbers HM 142602 to HM 142613, HM 990966, HM 990967 and JN 160690 to JN 160707 ( Table 3.4).

Pair wise alignment of *H. antonii* (HM 990967) and *H. bradyi* (JN 160704) showed that there was variation in 50 nucleotides out of 658 bp, amounting to 7.6 per cent difference between *H. antonii* and *H. bradyi*. Pair wise alignment of HM 142602 and HM 142613 showed that there was variation in 72 nucleotides out of 658 bp, amounting to 10.94 per cent difference between *H. antonii* and *H. theivora*.

**Table 3.3: Testing of food grade repellent for the persistence of odour**

Food grade repellent tested	Response
<b>Whole kernels</b>	
Methyl benzoxide 0.125 %	Strong odour
Methyl benzoxide 0.065 %	Strong to medium odour
Methyl benzoxide 0.025 %	Normal odour
<b>Split kernels</b>	
Methyl benzoxide 0.125 %	Very strong odour
Methyl benzoxide 0.065 %	Strong to medium odour
Methyl benzoxide 0.025 %	Normal to faint odour
<b>Whole kernels</b>	
Ortho-guaiacol (vanillin) 0.125 %	Medium odour
Ortho-guaiacol (vanillin) 0.065 %	Faint to normal odour
Ortho-guaiacol (vanillin) 0.025 %	Normal odour
<b>Split kernels</b>	
Ortho-guaiacol (vanillin) 0.125 %	Medium odour
Ortho-guaiacol (vanillin) 0.065 %	Medium odour
Ortho-guaiacol (vanillin) 0.125 %	Normal odour
<b>Whole kernels - untreated</b>	Normal odour
<b>Split kernels - untreated</b>	Normal odour

Table 3.4: List of TMB specimens deposited at NCBI

Species	Host	Location	Gen.bank accession number	Voucher specimen
<i>H. antonii</i>	Cashew	Puttur, Karnataka	HM 142602	DCR-01
<i>H. antonii</i>	Cashew	Pilicode, Kerala	HM 142603	DCR-02
<i>H. antonii</i>	Cashew	Madakkathara, Kerala	HM 142604	DCR-03
<i>H. antonii</i>	Cashew	Chintamani, Karnataka	HM 142605	DCR-04
<i>H. antonii</i>	Cashew	Paria, Gujarat	HM 142606	DCR-05
<i>H. antonii</i>	Cashew	Vengurle (Inorg. farm), Maharashtra	HM 142607	DCR-06
<i>H. antonii</i>	Cashew	Vengurle (Org. farm), Maharashtra	HM 142608	DCR-07
<i>H. antonii</i>	Cocoa	Vittal, Karnataka	HM 142609	DCR-08
<i>H. antonii</i>	Guava	IIHR, Bengaluru	HM 142610	DCR-09
<i>H. antonii</i>	Neem	Chintamani, Karnataka	HM 142611	DCR-10
<i>H. antonii</i>	Cashew	Kasaragod, Kerala	HM 990966	DCR-11
<i>H. antonii</i>	Cocoa	Puttur, Karnataka	HM 990967	DCR-12
<i>H. antonii</i>	Cashew	Belgaum, Karnataka	JN 160690	DCR-13
<i>H. antonii</i>	Cashew	Ela, Old Goa	JN 160691	DCR-14
<i>H. antonii</i>	Cashew	Bhubaneswar, Orissa	JN 160692	DCR-15
<i>H. antonii</i>	Guava	Puttur, Karnataka	JN 160693	DCR-16
<i>H. antonii</i>	Cashew	Andaman & Nicobar	JN 160694	DCR-17
<i>H. antonii</i>	Neem	Shanthigodu	JN 160695	DCR-18
<i>H. antonii</i>	Guava	Belgaum, Karnataka	JN 160696	DCR-19
<i>H. theivora</i>	Acalypha	Payyannur, Kerala	HM 142613	DCR-20
<i>H. theivora</i>	Cashew	Ela, Old Goa	JN 160697	DCR-21
<i>H. theivora</i>	Cocoa	Puttur, Karnataka	JN 160698	DCR-22
<i>H. theivora</i>	Acalypha	Ela, Old Goa	JN 160699	DCR-23
<i>H. theivora</i>	Cashew	Tura, Meghalaya	JN 160700	DCR-24
<i>H. theivora</i>	Cashew	Puttur, Karnataka	JN 160701	DCR-25
<i>H. bradyi</i>	Cocoa	Pollachi, Tamil Nadu	JN 160702	DCR-26
<i>H. bradyi</i>	Cocoa	Vittal, Karnataka	JN 160703	DCR-27
<i>H. bradyi</i>	Cocoa	Puttur, Karnataka	JN 160704	DCR-28
<i>H. bradyi</i>	Cashew	Tura, Meghalaya	JN 160705	DCR-29
<i>H. bradyi</i>	Cashew	Puttur, Karnataka	JN 160706	DCR-30
<i>H. bradyi</i>	Cashew	Belgaum, Karnataka	JN 160707	DCR-31
<i>P. maesarum</i>	Cashew	Puttur, Karnataka	HM 142612	DCR-32

## B. Screening of cashew varieties against TMB

The screening of the varieties against the incidence of TMB was continued during the year. The damage due to the infestation of pest was recorded in 0-4 scale from first fortnight of November, 2011 to March, 2012. (Grade 0 = no damage, 1 = 1-3 necrotic lesions, 2 = 4-6 coalescing lesions, 3 = more than 6 coalescing lesions and 4 = complete drying). The incidence of TMB was lower in Ullal-1 with a mean damage score of 0.12. This was followed by Ullal-2 (0.16), Dhana (0.17), VTH-174 (0.18) and Bhaskara (0.18). The incidence was higher in Ullal-4 (0.91) and NRCC Sel- 2 (0.86) (Fig. 3.1).

### 3.4.3 Incidence of TMB in trees with foliar spray of nutrients

#### 3.4.3.1 Foliar spray of major nutrients

##### Treatments

1. Urea
2.  $H_3PO_4$  (0.5%)
3.  $K_2SO_4$  (1%)
4. Urea 3% +  $H_3PO_4$  (0.5%)
5. Urea 3% +  $K_2SO_4$  (1%)
6.  $H_3PO_4$  (0.5%) +  $K_2SO_4$  (1%)

7. Urea (3%) +  $H_3PO_4$  (0.5%) +  $K_2SO_4$  (1%)
8. Control

The incidence of TMB was lower in  $K_2SO_4$  (1%) sprayed trees with a mean damage score of 0.79. In untreated control the incidence of TMB was higher with a maximum of 1.87 (Fig.3.2).

#### 3.4.3.2 Foliar spray of secondary and micro-nutrients

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

The incidence of TMB was lower in solubor (0.1%) sprayed trees with a mean damage score of 0.68. In untreated control the incidence of TMB was higher with a maximum of 2.73 ( Fig. 3.3).

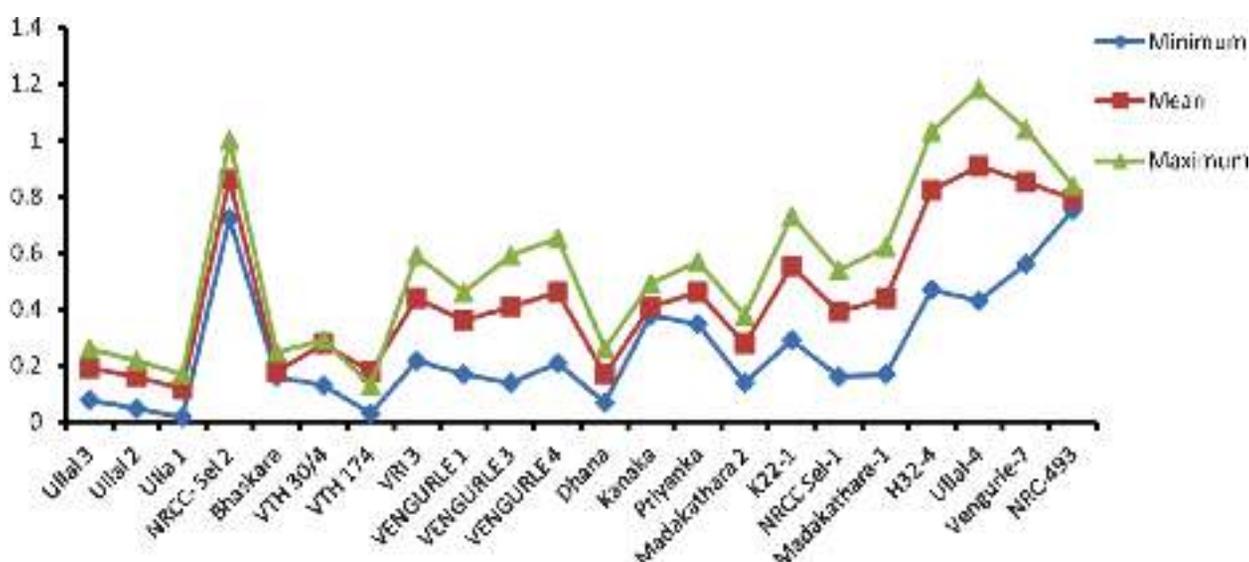


Fig. 3.1: Mean damage score of 22 cashew varieties against TMB

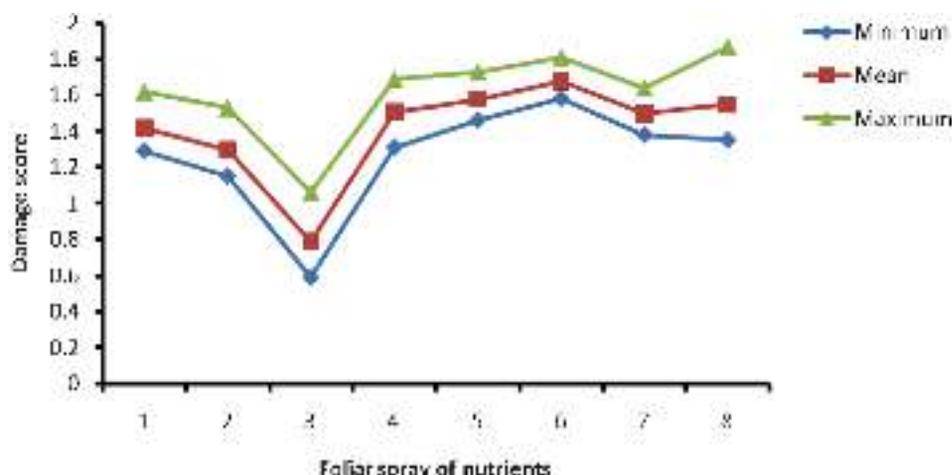


Fig. 3.2: Reaction of NRCC Sel-2 cashew variety with foliar application of major nutrients to TMB

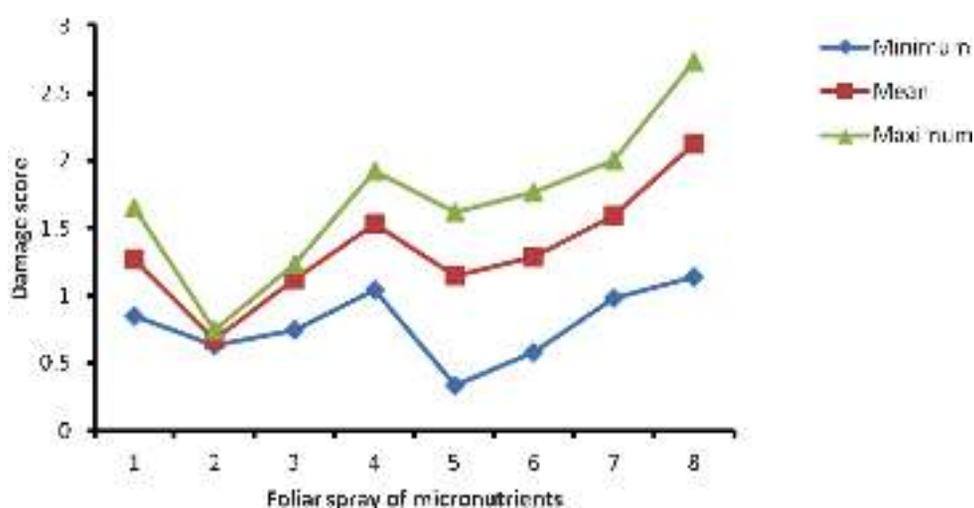


Fig.3.3: Reaction of NRCC Sel-2 cashew variety with foliar application of secondary and micronutrients to TMB

### 3.5 Biodiversity of arthropod fauna in cashew ecosystem

#### 3.5.1 Documentation of insect pests, natural enemies and other arthropod species associated with cashew

Monitoring of four species of TMB viz., *Helopeltis antonii*, *H. bradyi*, *H. theivora* and *Pachypeltis maesarum* was made in the cashew plots of DCR, Puttur during the peak period of activity (October, 2011 - March, 2012). *H. antonii* was the dominant species which accounted for 30.17 to 100 per cent (Table 3.5) of the TMB population during different months of observation. The damage due to TMB was around 40 per cent in few instances during this period.

Rearing of TMB was done continuously throughout the year by providing tender cashew shoots of cashew. The length of life cycle didn't vary much during the different months. The sex ratio was

worked out during different months which revealed that activity of male was more in most part of the year. Activity of female was prominent during March-April months. The other insect pests recorded during this season are furnished in Table 3.6. Activity of leaf miner was noticed throughout the year, while, other pests were active during flushing/flowering/fruiting periods.

Surveys conducted for natural enemies of TMB revealed the presence of six species of reduviid bugs, *Sycanus collaris* Fabricius, *Endocus inornatus* Stal, *Euagorus plagiatus* Burmeister, *Panthous bimaculatus* Distant, *Rihirbus trochantericus* Stal and *Lanca* sp. The monitoring of the activity of spiders was continued and another 20 species were recorded in addition to the 24 species recorded earlier (Table 3.7). These species belonged to the families araneidae, gnaphosidae, oxyopidae, salticidae, sparasside, tetragnathidae and theridiidae.

**Table 3.5: Species composition of TMB during the period of peak activity**

Month	<i>H. antonii</i>	<i>H. bradyi</i>	<i>H. theivora</i>	<i>Pachypeltis maesarum</i>
Oct 2011	50 (38.17)	10 (7.63)	30 (22.90)	41 (31.30)
Nov 2011	62 (59.08)	4 (3.81)	13 (12.38)	26 (24.76)
Dec 2011	153 (75.74)	4 (1.98)	20 (19.90)	25 (12.38)
Jan 2012	137 (76.97)	0 (0.00)	13 (7.30)	28 (15.73)
Feb 2012	76 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)
Mar 2012	46 (93.88)	0 (0.00)	0 (0.00)	3 (6.12)
Total	524 (70.72)	18 (2.43)	76 (10.26)	123 (16.59)

Figures in the parentheses indicate the percentage of total of TMB of all species collected

**Table 3.6: Insects pests other than TMB recorded during 2011-12**

Pests	Period of activity
Leaf miner ( <i>Acrocercops syngamma</i> )	April-March, 2012
Leaf roller ( <i>Caloptilia tisilea</i> )	September, 2011-February, 2012
Leaf webber ( <i>Orthaga exvinacea</i> )	September, 2011-February, 2012
Shoot tip caterpillar( <i>Hypotima (= Chelaria) haligramma</i> M.)	October-December, 2012
Loopers ( <i>Oenospila flavifuscata, Ischyia manlia, Pingasa ruginaria</i> )	October-November, 2011
Thrips ( <i>Rhyncothrips raoensis</i> G., <i>Scirtothrips dorsalis</i> H.)	November, 2011-March, 2012
Hairy caterpillars ( <i>Euproctis fraternae, Lymantria</i> sp.)	October, 2011-February, 2012
Aphid ( <i>Toxoptera odinae</i> )	October, 2011-January, 2012
Apple and nut borer ( <i>Thylocoptila paurosema</i> M.)	January-February, 2012
Mealy bug ( <i>Rostrococcus iceryoidens, Planococcus citri</i> and <i>Ferrisia virgata</i> )	November, 2011-March, 2012

**Table 3.7: Spiders associated with cashew**

Family	Scientific name	Common name	Season	General abundance
Araneidae	<i>Araneus bituberculatus</i> Simon	Orb-weaver	M	VC
	<i>Argiope pulchella</i> Thorell	Garden cross spider	W, S, M	VC
	<i>Cyrtarachne keralaensis</i> Thorell*	Grass jewel spider	S, M	VR
	<i>Cyrtarachne raniceps</i> Pocock**	Grass jewel spider	S, M	VC
	<i>Neoscona mukerjeri</i> Tikader	Common garden spider	W, S	VC
	<i>Neoscona poonaensis</i> Tikader	Common garden spider	W	VC
Gnaphosidae	<i>Poecilochroa barmani</i> Tikader*		M	R
Oxyopidae	<i>Oxyopes birmanicus</i> Thorell	Crossed lynx spider	S	C
	<i>Peucetia viridana</i> Stoliczka	Green lynx spider	S	R
Salticidae	<i>Bavia kairali</i> sp.nov	Scorpion jumpe	W, M	R
	<i>Brettus albolimbatus</i> Simon	Crescented jumper	M	R
	<i>Epeus</i> sp	-	W, S, M	VC
	<i>Hylus semicupreus</i> Simon	Heavy bodied jumper	W, S, M	VC
	<i>Myrmarachne ramurni</i> Narayan	-	M	R
	<i>Plexippus paykulli</i> Audouin	Small zebra jumper	W, S, M	VC
	<i>Plexippus petersi</i> Karsch	Small zebra jumper	W, S, M	VC

Continued.....

Family	Scientific name	Common name	Season	General abundance
Sparassidae	<i>Heteropoda</i> sp	Common house spider	W, S, M	VC
Tetragnathidae	<i>Tetragnatha viridorufa</i> Gravely	Green tetragnathid spider	M	VC
Theridiidae	<i>Achaearanea tepidariorum</i> C.L. Koch	Wall corner spider	W, M	VC
	<i>Theridion</i> sp.		M, W	VC

M - Monsoon, W - Winter, S - Summer; VC - Very common, VR - Very rare, R - Rare



*Araneus bituberculatus* Simon



*Bavia kairali* sp.nov



*Oxyopes birmanicus* Thorell



*Eriovixia laglazei* Simon



*Neoscona mukerjeri* Tikader



*Poecilochroa barmani* Tikader

### Spiders occurring in cashew ecosystem

## 4. POST-HARVEST TECHNOLOGY

### 4.1 Development of compact type drum roasting machine

Roasting characteristics of raw cashewnuts were studied in terms of loss in weight after roasting, whole kernel recovery and retention of surface colour of cashew kernels in varying size of the raw cashewnuts. It was observed that hardness of roasted cashewnuts decreased with increasing roasting temperature *i.e.*, 300 to 600°C) for the given size of the raw cashewnuts and period of exposure (10 to 120 sec.).

During roasting process raw cashewnuts, moisture was lost resulting in the reduction in its weight. Percentage loss of weight varied with size of the nuts, moisture content of the nuts and roasting temperature. Cashew kernels obtained after shelling and peeling, were analyzed for its surface colour characteristics in terms of reflectance values *i.e.*, L, a, b using spectrophotometer. Change in the colour from standard value indicated that colour value more pronounced in the case of larger size nuts than small nuts due to total surface area exposed to roasting temperature irrespective of roasting temperature in the range of 350 to 750°C.

### 4.2 National Agricultural Innovation Project (NAIP): A value chain on cashew for domestic and export market

#### 4.2.1 Performance evaluation of concentric drum type rotary grader

Considering the irregular shape of raw cashewnuts, a rotary sieve cylinder grading assembly is developed for minimizing clogging of nuts, compactness, self agitation and more opportunity to register with screen holes to grade raw cashewnuts based on its size. In order to evaluate the performance of the grader, length of the sieve drum was selected as 120 cm for conducting trials for various lengths *viz.*, 60, 90 and 120 cm on account of standard size of the perforated sheet *i.e.*, 120 x 240 cm. The sieve drum length was varied by wrapping the screen with thick sheet of 1.4 mm with the exposed screen conforming to the desired length. While conducting

the trials to find out the influence of inclination of the sieve drum, angle of repose of raw cashewnut at safe moisture content was considered which was 28°. As the preliminary trials on slope of rotary cylinder above 15° resulted very low separation efficiency, the inclination of drum was restricted between 6 and 15° at 3° interval.

Flow of nuts into the sieve cylinder was kept at the constant level of 150 kg h<sup>-1</sup> and acceleration due to gravity was fixed at sea level with a value of 9.81 m sec<sup>-2</sup>. The capacity of the rotary screen grader increases with increasing speed of rotation until a critical speed is achieved. At speeds greater than critical speed, the material does not cascade over the surface but is carried round by centrifugal force and grading is seriously impaired. Critical speed of cylinder with diameter 65 cm was calculated as 27 rotations per minute (rpm). In order to promote free movement of nuts along the periphery of the sieve cylinder, rotational speed is restricted below critical speed. Experiments were conducted at 8, 10, 12, 14 and 16 rpm using DC motor and gear assembly. Besides, as the performance of the grader also depends on bulk density of input material, ratio of input material was varied as 1:1, 1:2, 1:3, 2:1 and 3:1 to give bulk density value of raw cashewnuts between 568 to 591 kg m<sup>-3</sup>.

Fully matured and dried raw cashewnuts of four different size grades *viz.*, Small (Wc<20 mm), medium (20<Wc<22 mm), Big (22<Wc <24 mm) and very big (Wc>24 mm) each weighing 10 kg was mixed thoroughly and used to evaluate the performance of the concentric sieve grader developed for raw cashewnuts. The mixed raw cashewnut sample was fed into the grader through feed hopper at the rate of 100 kg h<sup>-1</sup> and the fraction of material collected at each product outlets was weighed separately. The material collected from each outlet was sieved using the grader itself repeatedly to quantify the various fractions in different outlets. The experiments were performed for various feed rates *viz.*, 150, 200, 250 and 300 kg h<sup>-1</sup> and data thus

obtained through replicated samples were subjected to statistical analysis. Using regression model technique, the optimum feed rate with higher grading efficiency was worked out for the developed mechanized grader for raw cashewnuts. Various parameters influencing the grading efficiency of concentric sieve grader for series type consecutive sieve drum are purity of the product obtained at the product outlets, fraction yield of the material collected in product outlets, degree of extraction and efficiency of screens.

#### 4.2.1.1 Effect of screen length on separation efficiency

Grading efficiency increased significantly as the screen length increased from 0.6 to 1.2 m. Increasing the length within this range increased the opportunity for the nuts to register with the sieve perforations as it moved from one end of the sieve cylinder to other end. Optimum value of length of the sieve cylinder was computed as 1.2 m for a fixed feed rate of 291.91 kg h<sup>-1</sup>, suggests that further increase in the length of screen would not result in significant increase in the grading efficiency.

#### 4.2.1.2 Effect of rotational speed on separation efficiency

Nut movement in the grading area depends on the rotational speed of the sieve cylinder and it influenced the grading efficiency. Increasing trend in the grading efficiency was observed for the decreasing rotational speed of the sieve cylinder. Lesser relative motion (drag effect) between the nuts and the cylinder at lower speeds ensure ample opportunity for nuts to pass through the sieve perforation.

#### 4.2.1.3 Effect of bulk density on separation efficiency

Bulk density of raw cashewnuts significantly influenced the response variable of sieve cylinder. When the feed mixture was denser, the amount of under size nuts in the feed material became lesser. As the ratio increases, the oversize nuts are more successful in reducing the number of sieve holes available for under size nuts and tend to convey the under size nuts further down the rotary screen.

#### 4.2.1.4 Effect of cylinder angle on separation efficiency

Relatively higher response found between angle of inclination and grading efficiency of rotary screen grader for raw cashewnut. Purity of the material obtained at the outlet showed a significant variation in the performance of the grader as the angle of sieve cylinder increased from 0.1 rad (6°) to 0.26 rad (18°). Tendency of the entering nuts gaining higher momentum at higher slope and missing the screen perforations in the upper layer could be the major reasons for the decrease in efficiency when angle of inclination was increased. Residence time of nuts inside sieve cylinder increased as the slope decreased and it provided greater opportunity for the nuts to register in the sieve holes during its travel from feed to discharge end.

#### 4.2.1.5 Effect of feed rate on grading efficiency

The effect of feed rate vs. grading efficiency was determined keeping other independent variables constant. The effectiveness of grading (E) showed a decreasing trend with increasing feed rate. Experimental data revealed that it could be possible to achieve grading efficiency up to 92.58 per cent using developed rotary grader for raw cashewnuts.

### 4.3 Moisture sorption isotherm of raw cashewnuts

A nut which is superficially seems to be healthy may carry microorganisms like fungi. Eight isotherm models were selected for fitting the experimental data of adsorption and desorption isotherms of raw cashewnuts. These models have two, three or four parameters and were estimated by using  $\Sigma$ -plot (Statistical package for curve fitting) software. Analysis of residuals was carried out in order to select the best model. Examination of the residuals detects inconsistencies between the data and the models. In the statistical analysis, it is assumed that the residuals are independent, have a zero mean and constant variance, following normal distribution. A plot of the residuals vs the predicted values helps to discover an adequacy in the model. The residuals were examined graphically by plotting each residual against predicted values. Any pattern other than a

uniform band around zero is an indication that one or more of the assumptions are violated.

The latent heat of vapourization of moisture present in the cashewnuts was determined from the slope of the plot of  $\log(P_c)$  vs.  $\log(P_v)$  curve. An equation was developed to describe the ratio of the latent heat of vapourization of moisture from cashewnuts to the latent heat of free water as a function of moisture content. BET (Brunauer, Emmett and Teller) and Caurie isotherm equations were used to determine the monolayer moisture of cashewnuts. The monolayer moisture content of BET equation was computed for the samples upto the water activity value of 0.592. But the Caurie's monolayer moisture content was computed for the entire range of water activity.

The concept of stability isotherm describes that the first derivative of the moisture sorption isotherm curve ( $dM/daw$ ) when plotted against water activity ( $aw$ ) result in the point where food products hold minimum moisture and this is important for storage. Change in free energy during moisture exchange between the cashewnuts and the surroundings is the energy required to transfer water molecules from vapour state to solid surface, or from solid surface to the vapour state. This is the quantity, which can be considered a measure of work done by the system to accomplish the adsorption or desorption process.

#### 4.3.1 Hygroscopic characteristics

Adsorption and desorption isotherm of raw cashewnuts at different temperatures showed a sigmoidal shape, typical to many agricultural commodities. This is basically due to heterogeneity of raw cashewnuts, which has outer shell, testa and kernel of different chemical composition. Water activity increased with increasing equilibrium moisture content for the specific temperature. Non-linear relationship existed between  $aw$  and EMC representing a sigmoid shape curve. The shape of the sorption isotherm could be divided into three different regions corresponding to strongly bound monolayer moisture (up to  $0.4 a_w$ ), linear region of less rigidly ( $0.4$  to  $0.7 a_w$ ) and capillary bound water and solvent or free water ( $>0.7 a_w$ ).

#### 4.3.2 Sorption hysteresis

The adsorption and desorption isotherms of raw cashewnuts exhibited the phenomenon of hysteresis in which the equilibrium moisture content was higher at a particular  $aw$  for desorption than for adsorption. The hysteresis effect with raw cashewnuts started just after  $0.43 a_w$  and gradually increased up to the end of isotherm at temperature of  $30^\circ C$ . Although, the same pattern followed at higher temperature, the difference between sorption hysteresis increased quantitatively.

#### 4.3.3 Sorption models

Henderson based on the quantitative criteria of various indices considered viz., mean relative per cent error (0.0494), standard error of estimate (0.011) and coefficient of determination (0.999), thereby making it the best equation to describe the desorption behaviour of raw cashewnuts. Using Modified Henderson's equation for desorption, the equilibrium relative humidity data was generated for raw cashewnuts at different temperatures and moisture contents. The slope of the plots between  $\log_{10}(P_c)$  and  $\log_{10}(P_v)$  gave the heat of vaporization ratio at different moisture contents.

#### 4.3.4 Monolayer moisture

The monolayer moisture content which is of significant importance to the physical and chemical stability of dehydrated materials with regard to lipid oxidation, enzyme activity, non-enzymatic browning, flavour components preservation, and structural characteristics, can be determined from the equilibrium sorption isotherms by means of BET and Caurie's equations. The monolayer moisture content as computed from BET equation ranged from 3.71 to 6.55 per cent d.b. in the case of adsorption and 5.05 to 8.44 per cent d.b. in the case of desorption within the temperature range of  $30$  to  $50^\circ C$ . In general, the monolayer value decreased as the temperature of sorption increased.

The Caurie's monolayer moisture ranged from 6.54 to 7.32 per cent d.b. for adsorption and from 7.36 to 8.14 per cent d.b. for desorption process in the temperature range of  $30$  to  $50^\circ C$ . Decreasing trend in monolayer values was observed for both adsorption

and desorption processes with the increase in temperature. While comparing the monolayer moisture obtained for raw cashewnuts, the values computed by BET equation was lower than employing Caurie's equation to determine monolayer moisture.

#### 4.3.5 Stability isotherm and free energy change

The free energy change or sorption isosteric heat equation can be expressed as a function of temperature and moisture content. The sorption isosteric heat computed from aw sorption isosteric model showed good agreements with the values calculated by the Clausius–Clapeyron equation. Polynomial equations of the form  $F=C+a*\exp(b*M)$  were fitted relating free energy, F (kJ kg<sup>-1</sup> mol) and moisture content, M, (% d.b.) of both adsorption and desorption processes of raw cashewnuts at different temperatures. It was observed that free energy change was higher in desorption process than in adsorption process at all the temperatures and moisture contents. Maximum value of free energy change of 15930.88 kJ kg<sup>-1</sup> mol was found with 5 per cent moisture content at 30°C in the adsorption process of raw cashewnuts, whereas the minimum value of 336.47 kJ kg<sup>-1</sup> mol<sup>-1</sup> was with 50 per cent moisture content at 50°C. Similar trends were also observed in desorption process *i.e.*, 24393 kJ kg<sup>-1</sup> mol<sup>-1</sup> with 5 per cent moisture content at 30°C and 402 kJ kg<sup>-1</sup> mol<sup>-1</sup> was with 50 per cent moisture content at 50°C.

#### 4.3.6 Binding energy

An Arrhenius plot of ln (aw) against 1/T gave the following equation  $\ln (aw) = -2405.30 (1/T) + 5.1068$  with a R<sup>2</sup> value of 0.997. The slope of the above equation *i.e.* -2405.30 was multiplied by R-value (8.314 kJ/kg<sup>-1</sup> mol<sup>-1</sup>) to get the binding energy related to primary bound water of raw cashewnuts. The value was obtained as -19997.66 kJ kg<sup>-1</sup> mol<sup>-1</sup>, which indicates that this binding energy is exothermic.

### 4.4 Texture profile analysis of raw cashewnuts

Raw cashewnuts do not have natural resting position owing to its irregular shape. Besides, cashew kernels are extracted mechanically by cutting along the boundary of two symmetrical shell halves. Considering the above reasons, it is desirable to

standardize testing and reporting procedures to interpret the experimental data meaningfully. Therefore, nuts were pre-damaged for the purpose of providing natural stability against distortion while applying shear force. About 1.5 mm of the shell was cut either from the concave or convex or stem end or apex end of the nut as per requirement for various orientations tested. Mini hacksaw (30 TPI) blade was used to cut desired thickness of the shell. The shear force was applied through selected cutting probe (HDP/BSK blade) in four different orientations along contour of the nut *viz.*, Position 1 (Parallel to major axis in the convex plane), Position 2 (Parallel to major axis in the concave plane), Position 3 (Parallel to minor axis at stem end) and Position 4 (Parallel to minor axis at apex end) of raw cashewnuts.

An examination of results indicated that peak failure force in majority cases, occurred within 50 per cent of the linear dimension of the nut in the direction of force applied irrespective of size and orientation of the nut. Increase in area of contact between probe (HDP/BSK blade) and nut along cutting path may be the cause for the above failure pattern. In few cases, nut experienced maximum failure force either equally in both first and second half of the nut sizes. It was observed that this type of failure seldom occurs; improper filling of kernel inside the nut could lead to this type of failure pattern.

#### 4.4.1 Influence of size and moisture on failure force of raw cashewnuts

Failure force generally increased from small to large size nuts and increase in moisture content. Peak force required for the nut failure ranged between 20.64 and 55.48 kg in the moisture range of 6.80 to 12.62 per cent d.b for the various positions. Increasing tendency of failure force was mainly due to softening of the nut by moisture and area over which blade shear depending on the size of the nut. Peak failure force recorded higher value for convex position *i.e.*, the direction parallel to major axis than in the direction of minor axis.

#### 4.4.2 Influence of size and moisture on failure energy of raw cashewnuts

Failure energy (area under the curve for specific depth) increased consistently for the

cashewnuts irrespective of size and moisture level of the raw cashewnuts. Nut hardening coupled with changes in nut moisture level led to variation in failure energy. Energy absorbed during application of force varied from 206.35 to 338 kg<sup>m</sup> for the various sizes under investigation. Changes in degree of hardness, size and moisture content altogether contributed to the enhancement of failure energy during textural profile analysis of raw cashewnuts.

#### 4.5 Performance evaluation of improved mechanized shelling machine

Raw cashewnuts of Benin origin was selected for the present study as it was available in the processing unit and exposed to steam using twin bottle type boiler of 320 kg per batch capacity for 12 min. raising its pressure level to 80 PSI. Steamed nuts, thus obtained were dried in ambient condition for 12-14 h and used for all the experiments. Initially, raw materials were fed into the shelling machine through feed hoppers attached to it. Nuts in the feed hopper were lifted up vertically by sliding component and transferred to the funnel. After positioning the nuts in the channel, nut was pushed down by a shoe against V- shaped blade. Due to the application of high force, nuts slits around its contour and split open by the blades provided on either side. Each machine was provided with two such shelling mechanisms deriving mechanical power from 0.37 kW single phase electric motor.



Improved mechanized shelling machine

After shelling a definite quantity of cashewnuts for a given period of time, various fractions *viz.*, whole kernels, broken kernels, unshelled nuts, kernel intact with shell, rejects and shells were separated manually and weighed. Graded nuts *viz.*, large, medium and small size and mixed nuts were used for each experiment to find out influence of size on shelling efficiency of mechanical shelling machine. Kernel intact with shells were extracted carefully and its fractions *viz.*, whole, broken and shell were weighed to work out the shelling percentage. As the cashewnuts could not be fed continuously while conducting the trials with auto feed system, due to irregular shape of the cashewnuts, experiments were also conducted by feeding various grades of the nuts manually. Due care was taken to avoid feeding only one cashewnuts at a time in to the channel for shelling. Nut fractions collected at the outlet were weighed to work out the performance of the mechanized shelling machine in terms of capacity, shelling efficiency, whole kernel recovery and percentage of kernel intact.

Operational capacity of manual, mechanical (MF – Manual feed) and mechanical (AF – Auto feed) were found to be in the range of 5.88 to 9.30, 8.38 to 14.52, 7.93 to 10.18 kg h<sup>-1</sup> for various size of nuts used for the trials. As the whole recovery has direct influence on the cost economics of processing, data collected pertaining to this term revealed that mechanical (MF) showed better results (98.63%) than other two methods employed indicating that feeding of nuts need to be regularized to improve the performance of the mechanized shelling machine. As far as the shelling efficiency is concerned, manual method found to be higher than mechanical either manual or auto feed, due to constant attention of the personnel operating the shelling unit. Nuts after shelling has kernel intact and requires extra labour to scoop out carefully to extract whole kernels involves more operating cost. Mechanical method of shelling showed better results than manual method. Comparison of operational cost revealed that mechanical method led to 5.16 times lesser than manual method of shelling and reduces the quantity of slit nuts after shelling to greater extent.

#### 4.6 Energy budgeting of cashewnut processing industries

Energy requirement of cashewnut processing units in the line of processing *i.e.*, human (man power), electrical and thermal energy were worked out based on the responded technical questionnaire from various regions *viz.*, West Bengal (83), Orissa (41) and Tamil Nadu (30). It was observed that generally energy utilized in the cashewnut processing units following drum roasting method is higher than steam boiling method as far as human and thermal energies are concerned.

Irrespective of the mode of processing, total human energy required was higher in peeling *i.e.*, in the range 0.69 to 44.75 MJ kg<sup>-1</sup> of raw cashewnuts followed by shelling process which is in the range of 0.53 to 36.72 MJ kg<sup>-1</sup> of raw cashewnuts depending on the region. Electrical energy is utilized in kernel drying and packaging operation in majority of cashewnut processing units and its value ranged between 0.01 and 1.47 MJ kg<sup>-1</sup> of raw cashewnuts. After the introduction of mechanized peeling machine and kernel grader especially in Odisha state, electrical power consumption increased in the line of processing. As far as thermal power is concerned, steam boiling and kernel drying operation in line or in an isolated way utilizes thermal power and mostly derived from by-product of the cashew industry, cashew shell cake / partially burnt cashew shells. Total thermal energy expended on cashewnuts processing was found to be in the range of 2.28 MJ to 13.65 MJ kg<sup>-1</sup> raw cashewnuts irrespective of mode of processing.

#### 4.7 Surface colour characteristics of cashew kernel grades

Cashew kernels are graded based on surface colour, size and wholesomeness for domestic and export market. Grading of cashew kernels is done manually in almost all cashewnut processing units in India. Degree of skillness and eye fatigue are the major factors influencing the efficiency of grading. Accounting for these shortcomings, an attempt was made to study the surface colour characteristics of

cashew kernels of identified grades and surface colour of cashew kernels obtained at various stages of processing.

Colour of both dorsal sides of the raw cashewnuts *i.e.*, apex of nut pointing to right considered as upper surface and towards left as bottom surface of the nut, was measured using spectrophotometer. The energy of the reflected light from the samples across the entire spectrum was measured. Filters, which rely on standard observer curves defining the amount of red, green and blue lights, required matching a series of colours across visible spectrum. The colour was measured using CIELAB scale at 10° observer and D65 illuminant. The display was set to CIE L, a, b colour coordinates.

The 'L' coordinate measures the value or luminance of a colour and ranges from black at 0 to white at 100. The 'a' coordinate measures red when positive and green when negative and 'b' measures yellow when positive and blue when negative. Preparation of white whole kernels is the ultimate aim of cashewnut processing, principally the deviation of white colour from original colour (Raw cashew kernel) was measured and worked out for the identification of particular grade. Average of reflectance value measured at six different locations *viz.*, top, middle and bottom of both dorsal sides were used for data analysis. Similarly, change in surface colour due to thermal treatment was measured from whiteness and yellowness index value. Difference in L- value measured for samples from standard surface colour *i.e.*, raw cashew kernel ( $\Delta$  dL) were 2.82, 2.70, 2.64, 0.24, -0.04, -1.42, -4.15, -3.45, and -3.29 for WW 180, WW 320, WW 400, SW 180, SW 320, SW 400, SSW, DW, KW and OW, respectively indicating the superiority of good kernels. Changes in the surface colour of the cashew kernels at different stages of processing *viz.*, raw material, after steam treatment, after shelling, after drying, after humidification, after manual and mechanical peeling and after final drying were measured and compared in terms of deflection from luminance value, whiteness and yellowness indices.



## 5. TRANSFER OF TECHNOLOGY

### 5.1 Establishment of demonstration plots

The demonstration plots established in farmers' fields at Puttur, Sullia and Buntwal 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 and technical advice was given as and when required. The financial assistance from NHM provided by DCCD, Kochi to the beneficiary farmers for meeting the expenditure of demonstrations was distributed to the farmers. These demonstration plots were frequently visited and technical advice was offered to farmers for demonstrating the technology and plot maintenance.

### 5.2 Exhibition / Demonstration

The Directorate conducted two exhibitions during the year for the benefit of farmers. During 23-24 December, 2011, National Level Exhibition was organized for the benefit of farmers. More than 15 organizations put up their exhibition stalls including institutes like CPCRI, Kasaragod, IISR,



Visit of dignitaries to DCR stall

Kozhikode and IIHR, Bengaluru along with DCR, Puttur. More than 500 farmers and other visitors took benefit of the exhibition. The DCR stall also made sale of various publications. On 29 February, 2012, exhibition was organized at Manchi village, Buntwal

taluk as part of cashew field day. More than 150 cashew farmers took benefit of the exhibition.

### 5.3 Training programme

A training programme was organized on Softwood Grafting Technique in Cashew on 16-17 March, 2012 in which 10 officials of Goa Plantation Development Corporation Limited were trained on latest aspects of softwood grafting and nursery management in cashew.

### 5.4 Innovative cashew farmers meet

On the occasion of Silver Jubilee celebrations (1986-2011) of this Directorate, innovative cashew farmers meet was organized to identify innovations on cashew farming from the farmers and felicitate them. Around 75 farmers including innovative and progressive farmers from different States participated in the meet. Mr. Vasavan, innovative cashew farmer from Kerala explained his innovative



Presentation by innovative farmer

method of managing tea mosquito bug infestation in cashew using red ants. Mr. Jayaram Kedaliya expressed his innovations in nursery management using silpaulin sheets and intercropping cashew with cocoa and pepper. The meet also discussed innovative approaches developed by Mr. (Late) Kumbadi Venkataramana Bhat for collecting fallen cashew apple with nut and the cashew variety 'Goa-1' developed by Mr. Prabhakar Keni, innovative

farmer from Goa. A farmer-scientist interaction followed where various aspects of cashew farming was discussed in detail with exchange of innovative ideas from farmers. The innovative farmers were felicitated for their contributions on this occasion.

### 5.5 National cashew stakeholders meet

National cashew stakeholders meet was organized on 23 December, 2011 in which more than 250 farmers participated. Farmers were given exposure to exhibition of DCR and cashew museum. Stakeholders interaction was held at the programme and farmers also shared information on performance of different cashew varieties and the results of various cashew production technologies in their fields. On the occasion, farmers and experts were given opportunity to interact on cashew related activities. Farmers were given information on cashew and cashew related problems during the interaction.

### 5.6 Agricultural education day

National science day was organized on 28 February, 2012 as Agricultural education day. Students from various high schools from Puttur and Bellare participated in the meeting. Students were also given exposure to various technologies developed in this Directorate. Importance of Agricultural education was explained to the students by Director of this Directorate and other guests.

### 5.7 Cashew field day

A Cashew field day was organized on 29 February, 2012 in Manchi village of Buntwal taluk



Address by demonstration farmer

in association with three cashew demonstration farmers of the village. About 150 farmers participated in the meeting. Field visits to demonstration plots were arranged in the morning session and later on group discussion cum seminar was organized for the benefit of participants.

### 5.8 Annual cashew day

Annual cashew day was organized at this Directorate on 9 March, 2012. Field visits were arranged at this Directorate and the ultra high density planting technique in a demonstration farmers plot at Papanadka in Irde village of Puttur taluk. Later a group discussion cum seminar was organized in which a strong feeling for forming a cashew farmers



Address by Director, DCR, Puttur

association was emerged. The house felt that with a small working committee with the guidance of DCR, Puttur can work out the modalities for forming a cashew growers society.

### 5.9 Advisory visits / Consultancy

The scientists of this Directorate were requested for technical advice / lectures on various aspects of cashew production by different organizations. The team of scientists made the following consultancy / lectures:

- Scientist of this Directorate served as a member of the team for evaluation and inspection of cashew nurseries and cashew frontline technology programmes in various parts of the country. The

team visited various newly planted cashew orchards of GFDC, Goa for inspection and evaluation in July, 2011.

- Scientists participated in a meeting on Good Agricultural Practices held at ICAR Research Complex for Goa, Ela, Goa on 23 July, 2011.
- Scientists participated in evaluation meeting of National Horticultural Mission in DK District held at Mangalore on 25 August, 2011.
- A team of scientists participated in the krishi mela at ZARS, Brahmavar, Karnataka on 17 October, 2011.
- A team of scientists participated in a farmers' meet at Kumbra sponsored by Dept. of Horticulture, Govt. of Karnataka on 9 September, 2011.
- A team of scientists from DCR conducted advisory visits to demonstration farmers' fields in the month of October, 2011.

A team of scientists or individual scientists participated as resource persons in the following cashew programmes:

- State level cashew seminar at College of Horticulture, Kolar on 3 February, 2012.
- Krishi mela organized by SKDRDP at Narimogaru village in Puttur taluk on 15 February, 2012.
- Seminar cum training programme on cashew organized by KVK and Academy for sustainable agriculture, Shimoga on 16 February, 2012.
- Cashew day programme at ARS, Chintamani on 2 March, 2012.
- Horticulture industry meet - 2012 at IIHR, Bengaluru and also ICAR Industry Interface meeting at IIHR, Bengaluru during 6-7 March, 2012.

## 5.10 Radio talks / TV Programmes

A series of recordings on various aspects of cashew production technologies were telecast by DD Chandana (Kannada) TV channel from April, 2011 onwards.

## 5.11 Visitors

Several individual visitors and around 20 batches of visitors including farmers, students and officials to this Directorate were taken to various experimental plots, cashew nurseries, cashew museum and laboratories and were explained about cashew cultivation practices and research findings of this Directorate.

## 5.12 Supply of planting material

About 3,00,000 cashew grafts of high yielding and recommended varieties were 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.

## 5.13 Soil sampling from cashew demonstration plots of farmers and their analysis for physico-chemical properties

Thirty three demonstration plots in and around Puttur, Karnataka were selected to evaluate the soil fertility status of cashew growing orchards. Surface (0-0.30 m depth) and sub-surface soil samples (0.31-0.60 and 0.61-0.90 m depths) were collected from the selected demonstration plots. Soil samples were taken before fertilizer application. The samples were processed and analyzed for pH, electrical conductivity, organic carbon, available N, P, K, Fe, Mn, Zn and Cu. Data on the physico-chemical properties indicated that the surface soils were acidic to near neutral with pH ranging from 4.90 to 6.62. Electrical conductivity varied between 0.016 to 0.44 dS m<sup>-1</sup>, indicating non-

saline in nature. The soils had low to high organic carbon content ranging from 4.96 to 15.9 g kg<sup>-1</sup>. The available N content of the soil ranged from low (150.40 kg ha<sup>-1</sup>) to high (723.50 kg ha<sup>-1</sup>), available P content: low (10.6 kg ha<sup>-1</sup>) to high (39.2 kg ha<sup>-1</sup>), available K: low (88.48 kg ha<sup>-1</sup>) to high (430.32 kg ha<sup>-1</sup>). DTPA extractable (available) Fe (7.48 to 112.3 mg kg<sup>-1</sup>), Mn (3.34 to 14.82 mg kg<sup>-1</sup>) and Cu (0.31 to 1.89 mg kg<sup>-1</sup>) were sufficient. DTPA-Zn content varied from deficient (0.32 mg kg<sup>-1</sup>) to sufficient (3.57 mg kg<sup>-1</sup>). Surface soils were found to contain more amounts of available nutrients than subsurface soils. A consistent decrease in the contents of available nutrients with the increase in soil depth was noted.

#### **5.14 Impact of cashew production technologies (CPTs) on area, production and productivity of cashew**

Impact assessment methodology for the study was finalized in consultation with experts. This will assess the technology wise impact of major cashew production technologies on the area, production and productivity of cashew and identify the cashew production technologies having significant impact on

the area, production and productivity of cashew. The methodology will also identify the determinants of adoption of cashew production technologies and field level constraints in adopting cashew production technologies and will aid in suggesting recommendations for better adoption.

A questionnaire was prepared for studying the impact of various cashew production technologies spread through AICRP cashew centers and private nurseries. This will measure the impact of CPTs on area, production and productivity in different areas of the country. This questionnaire will aid in identifying the determinants of adoption of cashew production technologies and field level constraints in various parts of the country.

Construction of an interview schedule for data collection from farmers is presently in progress. This schedule is designed to study area, production and productivity trends in different locations. It will also identify farm level determinants of adoption and the constraints faced by farmers so that future recommendations can be provided based on the same.



# CONCLUDED PROJECTS

## 6. CONCLUDED PROJECTS

### 6.1 Molecular characterization of germplasm of cashew

Project Leader : Dr. Thimmappaiah

Project Duration : 2008-2011

#### 6.1.1 Introduction

In India, DCR, Puttur has the single largest collection of cashew germplasm (527) maintained as clonal accessions in addition to the 1200 germplasm accessions maintained at AICRP - Cashew Centres. Though their evaluation is done on morphological descriptors many are agronomic in nature and their expression is influenced by the environment in which they are grown. Molecular markers provide an important tool as markers are less influenced by environment factors. There are various PCR based molecular assays available like RAPDs, ISSR, SSR, AFLPs *etc.* RAPD markers are relatively simple, inexpensive and fast, but reproducibility is somewhat questionable. However, they are still useful in diversity studies with germplasm. On the other hand, ISSR markers are highly reproducible than RAPD and does not require gene sequence information and targets microsatellite motif and have been found useful for genetic differentiation of genotypes. Similarly, SSR markers are very useful for germplasm characterization as they are more robust, highly reproducible but more expensive than others. Earlier 172 germplasm collections were characterized using different markers (RAPD, ISSR and Isozymes) and similarly 40 cashew varieties / elite lines were characterized using RAPD, ISSR and SSR markers. However, in the present study characterization of remaining germplasm collections maintained at National Cashew Field Gene Bank (NCFGB) was continued using informative markers of RAPD, ISSR and SSR.

#### 6.1.2 Objectives

- To fingerprint cashew varieties /accessions using RAPD, ISSR and SSR markers.
- To estimate the extent of genetic diversity in germplasm.
- To generate DNA profiles of varieties / accessions for identification and patenting purpose.

#### 6.1.3 Materials and methods

Plant materials: Cashew accessions (181) maintained at NCFGB, DCR, Puttur were utilized in this study. Total DNA was extracted from young cashew leaves following cetyltrimethylammonium bromide (CTAB) method with slight modification of Mneney *et al.* (1997).

RAPD markers: PCR reaction of RAPD was carried out with selected random primers (9-20) which were chosen for their consistency and scorability of bands.

ISSR analysis: The ISSR primers (8-10) of UBC sequence were used.

SSR markers: PCR of SSR was carried out with (9-10) selected primer pairs of microsatellite markers developed by Croxford *et al.* (2006).

#### 6.1.4 Results and discussion

##### 6.1.4.1 DNA extraction from germplasm

In the span of three years, DNA was extracted from leaf samples of 181 germplasm accessions maintained at Shanthigodu following CTAB buffer extraction procedure. The integrity of DNA was verified by electrophoresis on 0.8 per cent agarose and the DNA yield was estimated by recording absorbance in UV spectrophotometer. The yield of DNA varied from 15-1307  $\mu\text{g/ml}$  from 1.5 g leaf tissue.

##### 6.1.4.2 Molecular characterization of germplasm

###### a) Diversity analysis in 44 accessions using SSR

Forty four germplasm accessions from nine morphological clusters were fingerprinted with nine primer pairs of SSR markers of cashew as described by Croxford *et al.* (2005). A total of 24 bands were generated, of which 23 (95.8%) were polymorphic with number of polymorphic bands varying from 1 to 5. Genetic relatedness was assessed using Jaccard's similarity co-efficient which varied from 0.26 to 1.0. The average similarity of 0.55 indicated moderate diversity existing among the

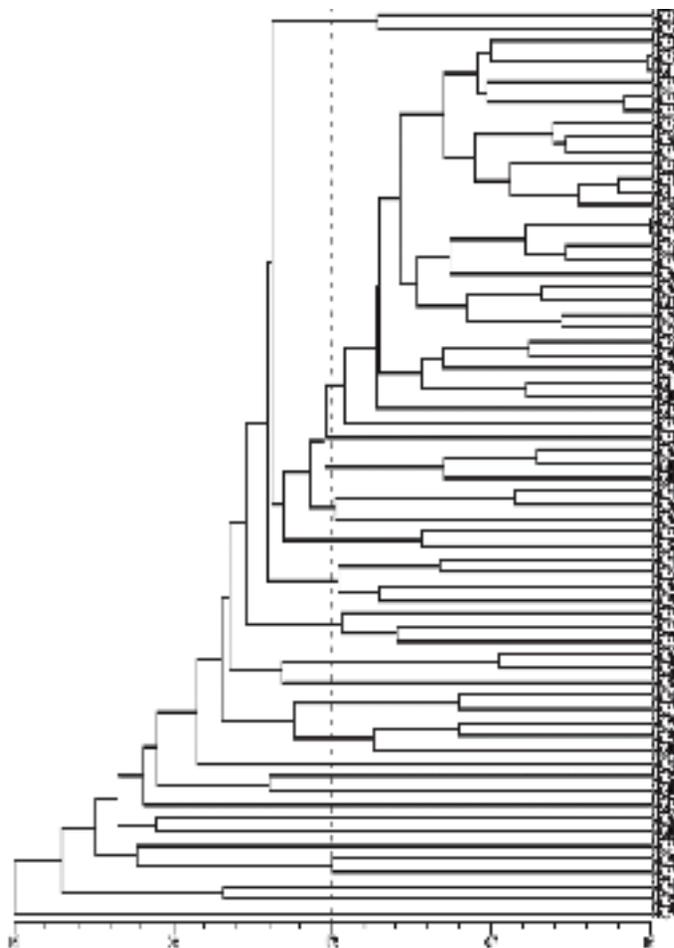
accessions. UPGMA dendrogram could distinguish 44 accession broadly into two clusters and further one of the clusters was divided into seven sub clusters. Among the accessions NRC-97 and NRC-12 were highly divergent and accessions like NRC-12 and NRC-67, NRC-71 and NRC-121, NRC-9 and NRC-126, NRC-111 and NRC-112 were highly similar.

**b) Molecular assessment of 67 accessions using RAPD, ISSR and SSR markers**

Sixty seven accessions (NRC 321-NRC 431) were finger printed using RAPD, ISSR and SSR markers. RAPD analysis was carried out using nine selected RAPD primers which generated 60 bands, of which 44 were polymorphic (73.3%). The number of polymorphic markers varied from 1 to 8 with an average of 7.3 polymorphic markers per primer. Among the primers used OPO-02, OPM-18, OPO-01 were highly informative. Genetic relatedness of the accessions was assessed based on their genetic

similarity values (Jaccard, 1908) which varied from 0.53 to 0.94. An average similarity of 0.75 indicated low diversity existing among the accessions. However, among the accessions NRC-335 and NRC-338 and NRC-362 and NRC-388 accessions were highly divergent and accessions NRC-338 and NRC-321 were genetically similar. UPGMA diagram could distinguish 67 accessions into 13 clusters (Fig.6.1).

ISSR analysis carried out with eight ISSR primers generated a total of 58 bands, of which 50 were polymorphic (86.2%) and produced an average number of 7.2 polymorphic bands per primer. Among the primers used UBC 857 was highly informative. Based on ISSR analysis, the similarity coefficient values (Jaccard, 1908) varied from 0.38-0.89 with an average similarity of 0.60 indicated low diversity existing among the accessions. However, accessions NRC 372 and NRC 369 were highly divergent. Cluster analysis with ISSR could distinguish 12 clusters.



**Fig.6.1: Cluster diagram of 67 accessions based on combined markers (RAPD+ISSR+SSR)**

Similarly, SSR analysis carried out with 10 SSR primer pairs generated 22 bands on high resolution agarose, of which 20 were polymorphic (90.9%) and produced on an average of 2.0 polymorphic bands per primer. Among the primers used, CS 14 was highly informative. The similarity coefficient varied from 0.25 to 1.00 with an average of 0.6 indicated low diversity existing in the accessions. Based on SSR, the UPGMA dendrogram could distinguish 14 clusters. Among the accessions NRC 394, NRC 400 and NRC 388 were highly divergent.

Markers data (130) of RAPD, ISSR and SSR were also combined and analyzed. The polymorphism of markers was 87.7 per cent and the similarity coefficient range of 0.52-0.83 with an average similarity 0.6 indicated low genetic diversity. However, by combined markers NRC-394 and NRC-388 was highly divergent. Dendrogram with combined markers could divide accessions into 21 molecular groupings.

#### c) **Molecular assessment of 60 accessions using RAPD and ISSR markers**

In all 60 accessions were characterized using both RAPD and ISSR markers. In the 1<sup>st</sup> set, 35 accessions were characterized using 20 RAPD primers and 10 ISSR primers. RAPD analysis carried out with 20 primers generated 138 bands, of which 81 were polymorphic (58.7%) with an average of 4.05 polymorphic bands / primer. The size of the amplicons varied from 200 to 5000 bp. The polymorphic information content (PIC) varied from 0.147 to 0.354 with an average PIC of 0.229. Similarly, marker index (MI) varied from 0.056 to 2.208 with an average MI of 0.965. The similarity coefficient (Jaccard, 1908) between accessions varied from 0.63 to 0.88, the lowest was between NRC-456 and NRC-468 and the highest was between NRC-448 and NRC-452. By cluster analysis, 11 clusters could be distinguished in 35 accessions.

ISSR analysis carried out with 10 primers generated 88 bands, of which 47 were polymorphic (53.4%) with an average of 4.7 polymorphic bands /

primer. The size of the amplicons varied from 200 to 6000 bp. The PIC content varied from 0.092 to 0.360 with an average of 0.207. Similarly, the MI varied from 0.184 to 2.160 with an average of 1.060. The similarity coefficient between accessions varied from 0.58 to 0.89, with an average of 0.76 indicated low diversity existing among the accessions. Based on ISSR, NRC-452 and NRC-448 were similar and NRC-455 and NRC-456 were highly divergent. By cluster analysis, 35 accessions could be grouped broadly into three major groups which could be further divided into 2-3 sub groups.

The markers of RAPD and ISSR were combined and analyzed. In all a total of 226 bands were obtained, of which 128 were polymorphic (56.6%) with an average of 4.26 polymorphic bands/ primer. The PIC content varied from 0.092 to 0.355 with an average of 0.216. Similarly the MI of primers varied from 0.184 to 2.208 with an average of 0.986. Among the primers, OPO-02, OPM-18, UBC-53 and UBC-303 of RAPD and UBC-857 and UBC-825 of ISSR were effective in distinguishing the accessions. The similarity coefficient values (Jaccard, 1908) between pair of accessions varied from 0.58 to 0.89 with an average similarity of 0.73 indicated low diversity existing among the accessions. However, the low similarity coefficient of 0.58 between NRC-459 and NRC-450 indicated that these accessions were relatively divergent. Cluster analysis done grouped 35 accessions into 10 clusters.

In another set, 25 germplasm accessions were characterized using RAPD and ISSR primers. RAPD analysis with eight random primes generated 64 bands of which 36 were polymorphic (56.3%) with an average of 4.5 polymorphic bands / primer. The PIC of primers varied from 0.109 to 0.364 with an average of 0.191. Similarly, marker index (MI) varied from 0.334 to 2.579 with an average of 0.945. The length of amplicons varied from 390-1250 bp. Based on RAPD, NRC-346 was highly divergent and NRC-360 and NRC-392 were highly similar. By cluster analysis, seven clusters could be distinguished.

In ISSR analysis, with nine primers 74 bands were generated of which 48 were polymorphic (64.9%) with an average of 5.3 polymorphic bands / primer. The PIC content varied from 0.137 to 0.301 with an average of 0.202. Similarly the MI varied from 0.549 to 2.106 with an average of 1.110. The size of the amplicons varied from 275 to 2500 bp. Based on ISSR, NRC-360 and NRC-350 were similar and NRC-331 and NRC-340 were highly divergent. By cluster analysis 25 accessions could be grouped into six groups.

By combining the markers (RAPD + ISSR), a total of 138 bands were detected of which 84 were polymorphic (60.9%) with an average of 4.9 polymorphic bands per primer. The PIC content varied from 0.109 to 0.301 with an average of 0.197. Similarly, MI varied from 0.320 to 2.105 with an average of 1.032. Among the primers, P-42 and P-34 of RAPD and UBC-856 and UBC-857 of ISSR were efficient in distinguishing the accessions. The similarity co-efficient between different pairs of accessions varied from 0.66 (NRC-340 and NRC-323) to 0.893 (NRC-360 and NRC-356) with an average similarity of 0.78 indicated low diversity existing among the accessions. The cluster analysis separated 25 accessions into 6 clusters.

### 6.1.5 Conclusions

DNA was isolated from leaf samples of 181 germplasm accessions maintained at NCFGB following CTAB buffer extraction procedure. Forty four diverse germplasm accessions from nine morphological clusters were fingerprinted with nine primer pairs of SSR markers of cashew and observed moderate genetic diversity. Sixty seven accessions were characterized using RAPD, ISSR and SSR markers and observed low genetic diversity. Similarly, 60 new accessions were characterized with same markers and recorded low genetic diversity among the accessions. However from these accessions, highly divergent and similar types were identified.

## 6.2 Development of INM package for commercially important plantation crops - Microbial inoculant based nutrient management in cashew (DBT project)

Project Leader : Dr. N. Yadukumar  
(February, 2008-April, 2010)  
Dr. T.R. Rupa  
(May, 2010-March, 2011)

Project Duration : 2008 - 2011

### 6.2.1 Introduction

The production of cashew grafts currently is on the rise, with the expansion in cashew cultivation and the increase in average tree density in orchards. Enhancement of growth rate using biofertilizers and production of healthy grafts would lower costs in the nursery and lower the price of grafts. Furthermore, young seedlings planted in orchards are highly sensitive to uncongenial environmental conditions, damage by pests, and competition from weeds. Improvement of plant establishment in the orchard and increased growth rates would be beneficial, as commercial yields would be reached earlier. However, inoculation of cashew seeds with biofertilizers has not received much attention in nursery and newly planted cashew grafts. Moreover, scanty information is available on their use in conjunction with inorganic fertilizers. Therefore, it is of great practical importance to study the combined effect of biofertilizers containing N-fixer (*Azotobacter*), P-solubilizer, Arbuscular Mycorrhizal Fungi (AMF) and *Pseudomonas* each having a specific role to play in plant growth and yield. Investigating the possibility of exploiting the beneficial effects of biofertilizers in cashew seedlings production and newly planted cashew grafts is of paramount importance.

### 6.2.2 Objectives

- Exploitation of microbial inoculants (AMF, *Azospirillum*, P-solubilizers and *Pseudomonas fluorescens*) for the production of healthy cashew plants in the nursery for establishment and growth in the field.
- Integrating microbial inoculant technology (AMF, *Azospirillum*, P-solubilizers and *Pseudomonas fluorescens*) as a component of INM in cashew and quantification of the long-term beneficial

effect in newly established gardens.

- Evaluation of effect of incorporating microbial inoculant technology in the integrated nutrient management in existing gardens.
- Nutrient analysis of the system involving biofertilizers, litter recycling and different levels of chemical nutrients supplied and evolving a package of recommendations for cashew.

### 6.2.3 Material and methods

#### 6.2.3.1 Nursery trial

A Nursery trial was carried out to study the effect of different combination of biofertilizers and chemical fertilizers on cashew seedlings and grafts. Cashew seedlings were raised in the nursery bags and different combination of biofertilizers and chemical fertilizers were applied in the poly bag containing the potting mixture (1:2:3 FYM: Sand: Soil) while sowing seeds. Microbial inoculants including *Azospirillum* (5g), *Pseudomonas* (5g), AMF (2.5g), and P-solubilizer (5g) were applied together as band, 3-5 cm below the seed and covered with soil, above which seeds were sown as stalk end upwards. In another batch, initially seedlings were raised in nursery bags as explained above and when seedlings were two months old scion Bhaskara variety was grafted on seedlings and maintained for another one month. Subsequently, the grafts were treated with different biofertilizers and combination of biofertilizers and chemical fertilizers. Cashew seedlings and grafts required for field studies were raised in the nursery with and without biofertilizer inoculation. The treatment details are furnished below:

#### Treatments

1. Control
2. Biofertilizer consortium (BFC)\*
3. BFC alone
4. 50% NPK + BFC
5. 100% NPK\*\* + BFC

\**Azospirillum* (5g), *Pseudomonas* (5g), AMF (2.5g), and P-solubilizer (5g).

\*\* 5 g N (11 g urea), 1.25 g P (6.25 g rock phosphate) and 1.25 g K (2 g muriate of potash) per poly bag.

#### 6.2.3.2 Field trial (Newly planted cashew grafts and seedlings)

Cashew grafts and seedlings of Bhaskara variety raised in the nursery with different treatments as explained under nursery trial were transplanted

in the field. Different biofertilizers and inorganic fertilizers as described below were applied to newly planted cashew grafts and seedlings.

#### Treatments

1. Control
2. \*100% NPK
3. 25% NP + 100% K + \*\*BFC
4. 50% NP + 100% K + BFC
5. 75% NP + 100% K + BFC
6. 100% NPK + BFC
7. BFC alone.

\*100% NPK: 110 g Urea + 125 g Rock phosphate + 20 g Muriate of potash/plant.

\*\*BFC: *Azospirillum*: 50 g/plant, *Pseudomonas*: 50 g/plant, AMF: 5 g/plant, P-solubilizer: 25 g/plant.

#### 6.2.4 Results and discussion

The rootstocks that received biofertilizer consortia were very vigorous with healthy growth. Plant height, stem girth, stem dry weight, leaf dry weight and total biomass of cashew rootstocks were significantly higher in biofertilizer consortia compared to control (Table 6.1). The increase in plant height, stem girth, stem dry weight, leaf dry weight and total biomass was about 16.3, 19.4, 48.4, 62.6 and 57.3 per cent, respectively in biofertilizer consortia over control. The number of leaves produced per plant and leaf area showed an increase of about 75.0 and 46.1 per cent, respectively in biofertilizer consortia over control but the increase was not statistically significant. The root dry weight was also higher in biofertilizer consortia treated plants. The beneficial effects on root dry weight observed may be a result of the inoculation of *Azospirillum*, which play a role in stimulation of root colonization by AMF. No significant difference in growth parameters between the treatments 50% NPK + biofertilizer consortia and 100% NPK + biofertilizer consortia was observed. The growth of cashew rootstocks was adversely affected in 100% NPK treatment.

The population of bacteria, fungi, actinomycetes, N-fixers and P-solubilizers in the soil treated with biofertilizer consortia was significantly higher than the populations in other treatments tested in this study (Table 6.2). About 37.1, 28.8, 39.5, 53.4 and 55.6 per cent increase in the population of bacteria, fungi, actinomycetes, N-fixers and P-solubilizers, respectively were recorded in

biofertilizer consortia as compared to control. Dehydrogenase activity, which is used as an indicator of microbial activity of soil significantly increased in soils with the application of biofertilizer consortia followed by 50% NPK + biofertilizer consortia treatments. The increase in dehydrogenase activity in the treatments biofertilizer consortia, and 50% NPK + biofertilizer consortia were 96.8 and 76.5 per cent, respectively over control. A significant reduction in soil dehydrogenase activity occurred with the application of 100% NPK. The results of the present study indicate that the higher dose of NPK fertilizer to cashew seedlings in the nursery may have negative impact on soil microbial population and dehydrogenase activity.

The organic carbon content was significantly higher in soil treated with biofertilizer consortia followed by 50% NPK + biofertilizer consortia as compared to other treatments. The increase in organic carbon content in biofertilizer consortia and by 50% NPK + biofertilizer consortia treatments was about 22.9 and 16.4 per cent, respectively. The available P and K contents were significantly higher in all the treatments compared to control but the maximum increase in available P (19.4%) and K (38.5%) was observed with 100% NPK + biofertilizer consortia treatments. This could be attributed to the nitrogen fixation ability of *Azospirillum*, better P mobilization and enhanced uptake of nutrients due to AMF application and also with external application of nutrients. DTPA extractable Fe, Mn, Zn and Cu contents were significantly higher in biofertilizer consortia as compared to control. The increase in DTPA extractable Fe, Mn, Zn and Cu was about 31.6, 66.2, 54.4 and 140.1 per cent, respectively as compared to control. This suggests that these microbial fertilizers solubilize the available micronutrient pools in the soil.

Cashew grafts and seedlings of Bhaskara variety raised in the nursery with and without biofertilizer consortia under nursery trial were transplanted in the field. Effect of biofertilizer consortia (*Azospirillum*: 50 g, *Pseudomonas*: 50 g, AMF: 5 g, P-solubilizer: 25 g per plant) separately and in different combinations with chemical fertilizers on the growth of newly planted cashew grafts and seedlings were recorded at 4<sup>th</sup>, 7<sup>th</sup>, 11<sup>th</sup> and 14<sup>th</sup> month after planting. The results revealed that at 4<sup>th</sup> and 7<sup>th</sup> month after planting, the treatment of 50%

NP+100% K+biofertilizer consortia produced the highest values in all growth parameters compared with other treatments. While at 11<sup>th</sup> and 14<sup>th</sup> month after planting, the treatment 100% NPK (110 g urea + 125 g rock phosphate + 20 g muriate of potash/plant) + biofertilizer consortia resulted in the highest values in all growth parameters. Soil samples were collected from the field four months after treatment at 0-30 and 31-60 cm depths one metre away from the base of the tree and analysed for nutrient contents and microbial population. Higher content of organic carbon, available N, P and K, and Exch. Ca and Exch. Mg were observed in 50% NP+100% K+BFC, 75% NP+100% K+BFC and 100% NPK+BFC as compared to other treatments. The application of biofertilizer consortia resulted in larger population of bacteria, fungi, actinomycetes, N-fixers and P-solubilizers followed by the treatment 25% NP+100% K+biofertilizer consortia. Dehydrogenase activity also followed the similar trend. The results indicated that the application of biofertilizer consortia with low fertilizer levels exhibited a larger population size of bacteria, fungi, actinomycetes, N-fixers and P-solubilizers, and dehydrogenase activity. The percentage of N, P and K in index leaves was considerably higher in biofertilizer consortia+NPK treated plants as compared to the control. The highest N (1.89%), P (0.22%) and K (0.98%) contents were obtained by 100% NPK+biofertilizer consortia treated plants. The results of the present study indicated that combined application of biofertilizer consortia along with N, P and K fertilizer may increase the efficiency of fertilizer use at different fertilizer levels.

Economics of application of biofertilizers for raising cashew seedlings / grafts in nursery has been worked out. There was not much variation in cost of production of cashew grafts among treatments. The cost of production of 100 cashew grafts under different treatments has been found as ₹ 1456/- (control), ₹ 1466/- (100% NPK), ₹ 1521/- [Biofertilizer consortia (BFC\*)], ₹ 1531/- (100% NPK+BFC) and ₹ 1526/- (50% NPK+BFC). All the five treatments under study have been found economically better with a B:C ratio of 1.373, 1.364, 1.315, 1.307 and 1.311 in control, 100% NPK, BFC, 100% NPK+BFC and 50% NPK+BFC, respectively (Table 6.3).

**Table 6.1: Effect of biofertilizers on growth of cashew rootstocks**

Treatment	Plant height (cm)	Stem girth (cm)	No. of leaves/plant	Leaf area (cm <sup>2</sup> )	Stem dry weight (g)	Leaf dry weight (g)	Root dry weight (g)	Total biomass (g)
Control	35.5	3.35	16.0	45.1	3.14	3.85	1.59	8.58
100% NPK	30.0	3.05	17.5	45.2	1.95	2.61	0.84	5.40
Biofertilizer consortia	41.3	4.00	28.0	65.9	4.66	6.26	2.59	13.5
100% NPK+ Biofertilizer consortia	33.8	3.50	17.5	48.5	3.37	3.98	2.00	9.4
50% NPK+ Biofertilizer consortia	32.9	3.65	16.5	61.6	3.51	4.38	2.43	10.3
CD (p= 0.05)	3.99	0.164	ns	ns	1.45	0.79	1.69	1.88

**Table 6.2: Effect of biofertilizers on soil microbial population and dehydrogenase activity**

Treatment	Bacteria x 10 <sup>5</sup> g <sup>-1</sup>	Fungi x 10 <sup>4</sup> g <sup>-1</sup>	Actinomycetes x10 <sup>5</sup> g <sup>-1</sup>	N-fixers x10 <sup>4</sup> g <sup>-1</sup>	P-solubilizers x 10 <sup>5</sup> g <sup>-1</sup>	Dehydrogenase activity (μgTPF/g dry soil/24 h)
Control	106.59	31.52	39.92	3.88	18.77	22.73
100% NPK	98.60	20.35	30.81	3.80	14.34	18.85
Biofertilizer consortia	146.09	40.60	55.68	5.95	29.20	44.73
100% NPK+ Biofertilizer consortia	110.34	30.29	35.81	4.10	16.31	26.90
50% NPK+ Biofertilizer consortia	115.98	36.91	36.80	4.58	18.90	40.11
CD (p= 0.05)	11.81	4.35	3.81	0.52	2.16	3.80

**Table 6.3: Economic analysis of different treatments for raising cashew seedlings / grafts in nursery**

S.No.	Particulars of nursery operations	Control	100% NPK	Biofertilizer consortia (BFC)	100% NPK + BFC	50% NPK + BFC
1	Cost of polybag (25 cm x 15 cm, 300 gauge)	68.6	68.6	68.6	68.6	68.6
2	Potting mixture 1:1:1 (sand: soil: cow dung)	215.2	215.2	215.2	215.2	215.2
3	Cost of seed	64.0	64.0	64.0	64.0	64.0
4	Ribbon (30 cm x 30 cm, 100 gauge)	5.75	5.75	5.75	5.75	5.75
5	Cap (20 cm x 54 cm, 200 gauge)	17.25	17.25	17.25	17.25	17.25
6	Shade net	38.8	38.8	38.8	38.8	38.8
7	HDPE Black 300 gauge sheet	16.0	16.0	16.0	16.0	16.0
8	Silpauline sheet 150 GSM	70.66	70.66	70.66	70.66	70.66
9	Hose pipe	4.0	4.0	4.0	4.0	4.0
10	Scion sticks	100.0	100.0	100.0	100.0	100.0
11	Maintenance of scion bank	139.5	139.5	139.5	139.5	139.5
12	Preparation of grafts and maintenance	221.9	221.9	221.9	221.9	221.9
13	Plant protection measures	7.0	7.0	7.0	7.0	7.0
14	Irrigation charges	44.8	44.8	44.8	44.8	44.8
15	Miscellaneous items like GI wires, ropes, tools, etc.	7	7	7	7	7
16	N, P and K fertilizer	-	9.386	-	9.386	4.693
17	BFC	-	-	65.0	65.0	65.0
	Cost of cultivation	1456	1466	1521	1531	1526
	Gross returns	2000	2000	2000	2000	2000
	Net returns	544	534	479	469	474
	B:C ratio	1.373	1.364	1.315	1.307	1.311

### 6.2.5 Conclusions

The effect of biofertilizer consortia (*Azospirillum*: 5 g, *Pseudomonas*: 5 g, AMF: 2.5 g and P-solubilizer: 5 g per polybag) with or without inorganic fertilizers on the growth of cashew rootstocks and soil properties indicated that biofertilizer consortia significantly increased the plant height, stem girth, stem dry weight, leaf dry weight, root dry weight and total biomass of cashew rootstocks. The rootstocks that received biofertilizer consortia were found to be very vigorous with healthy growth. The application of

biofertilizer consortia resulted in the largest population of bacteria, fungi, actinomycetes, N-fixers and P solubilizers and, dehydrogenase activity. While the treatment with 100% NPK (11 g urea, 6.25 g rock phosphate and 2 g muriate of potash) inhibited the growth parameters of the cashew rootstocks and also resulted in the lowest level of soil microbial activity. There was not much variation in cost of production of cashew grafts among treatments. Effect of biofertilizer consortia (*Azospirillum*: 50 g, *Pseudomonas*: 50 g, AMF: 5 g, P-solubilizer: 25 g per plant) separately and

in different combinations with chemical fertilizers on the growth of newly planted cashew grafts and seedlings showed that at 4<sup>th</sup> and 7<sup>th</sup> month after planting, the treatment of 50% NP + 100% K + biofertilizer consortia produced the highest values in all growth parameters compared with other treatments. While at 11<sup>th</sup> and 14<sup>th</sup> month after planting, the treatment 100% NPK (110 g urea + 125 g rock phosphate + 20 g muriate of potash/plant) + biofertilizer consortia resulted in the highest values in all growth parameters. The results also indicated highly significant increases in the nitrogen, phosphorus and potassium content of the leaves with 100% NPK + biofertilizer consortia treatment as compared with control.

### 6.2.6 Publications

Rupa, T.R., Yadukumar, N., Vidya, B.R. and Indushree. 2010. Effect of biofertilizers on growth of cashew rootstocks and soil properties. National Seminar on Developments in Soil Science - 75<sup>th</sup> Annual Convention of the Indian Society of Soil Science, 14-17 November, 2010, Indian Institute of Soil Science, Bhopal.

Rupa, T.R., Yadukumar, N., Vidya, B.R. and Indushree. 2012. Effect of biofertilizers on growth of cashew rootstocks and soil microbial activity. *Cashew News*, July-December, 2011, Vol. 16 (2): 5-6.

### 6.3 Rejuvenation of trees of high density cashew orchards through canopy management

Project Leader : Dr. N. Yadukumar (2006-2010)  
Dr. M.G. Nayak (2010-2011)

Project Associate : Dr. M.G. Nayak (2006-2010)

Project Duration : 2006-2011

#### 6.3.1 Introduction

The studies indicated that high density planting system with population ranging from 384 to 625 plants/ha can be maintained up to 10-12 years in two varieties tested at DCR, Puttur. After that, thinning of population to 50 per cent has been recommended so that reduction in yield can be avoided. Alternatively, it is suggested to take up limb pruning and maintaining a good canopy and thereafter pruning the overlapping branches. In

case, the existing variety is not performing well, top working with new variety can also be tried so that yield potential can be increased. Keeping this in view, certain pruning techniques like pruning of the branches to reduce canopy and also application of paclobutrazol which has growth retardant action were attempted in this study.

#### 6.3.2 Objective

- Standardize pruning techniques to be subsequently followed in limb pruned and top worked trees to maintain high yield for long period.

#### 6.3.3 Material and methods

##### Treatments

- Pruning at 1 m height of the branches emerging after limb pruning (decrowning) or top working once in a year.
- Pruning at 1 m height of the branches emerging after limb pruning (decrowning) or top working twice in a year.
- Treatment 1 and application of paclobutrazol @ 4 ml *a.i./tree/year*.
- Treatment and application of paclobutrazol @ 8 ml *a.i./tree* once in two years.
- No further pruning after limb pruning (control).

Design : RBD

Replications : 4

Variety : Bhaskara

#### 6.3.4 Results and discussion

##### 6.3.4.1 Effect of canopy management treatments on plant growth

The tree height, canopy height and spread of the trees treated with paclobutrazol @ 4 and 8 ml *a.i./tree* once in a year and once in two years were 50 per cent lower than the trees receiving one or two prunings subsequent to initial limb pruning (Table 6.4) as well as control (No pruning further after initial limb pruning).

Table 6.4: Effect of canopy management treatments on tree height and canopy spread

Treatments	Top worked on VRI-1 (12 years old) with Bhaskara		Bhaskara (Seven years old)	
	Tree height (m)	Canopy spread (m)	Tree height (m)	Canopy spread (m)
Pruning at 1 m height of the branches emerging after limb pruning (decrowning) or top working once in a year	4.43	5.1	4.47	5.15
Pruning at 1 m height of the branches emerging after limb pruning (decrowning) or top working twice in a year	4.05	4.45	3.90	4.41
Treatment 1 and application of paclobutrazol @ 4 ml <i>a.i./tree/year</i>	2.51	2.55	2.08	1.98
Treatment and application of Paclobutrazol @ 8 ml <i>a.i./tree</i> once in two years	3.93	2.61	2.13	2.01
No further pruning after limb pruning (control)	25.93	4.75	4.75	5.25
CD (p=0.05)	0.67	0.41	0.50	0.51

The lateral shoot length of VRI-1 variety ranged between 7.8 cm to 38.6 cm in trees receiving different canopy management treatments. The lowest lateral shoot length of 7.8 cm was observed in trees receiving 4 ml *a.i.* paclobutrazol/year and the highest lateral shoot length of 38.6 cm was observed in the trees receiving pruning once in a year after limb pruning. In seven years old Bhaskara variety the lateral shoot length was as minimum as 5.1 cm in paclobutrazol applied trees. Whereas, in trees treated with pruning once or twice in a year, the lateral shoot length was 36.2 and 41.6 cm, respectively. The number of flowering laterals in paclobutrazol treated

trees were almost ten times higher (34 and 38) than in the trees treated with pruning once in a year and twice in a year (3.0 and 2.4, respectively). No specific trend was observed in the production of non flowering laterals with different treatments (Table 6.5).

Higher nut yield was obtained in trees of VRI-1 receiving paclobutrazol compared to trees receiving pruning treatments and no further pruning after limb pruning (2.68, 2.97 and 3.50 kg nut yield/tree, respectively). Similar effect was noticed in case of Bhaskara variety (Table 6.6).

**Table 6.5: Effect of canopy management treatments on lateral shoot length, number of flowering laterals, and number of non flowering laterals**

Treatment	Year	Top worked on VRI-1 (12 years old) with Bhaskara			Bhaskara (Seven years)		
		Lateral shoot length (cm)	No. of flowering laterals/m <sup>2</sup>	Non flowering laterals/m <sup>2</sup>	Lateral shoot length (cm)	No. of flowering laterals/m <sup>2</sup>	Non flowering laterals/m <sup>2</sup>
Pruning at 1 m height of the branches emerging after limb pruning (decrowning) or top working once in a year	2009	38.6	6.6	9.4	41.6	3.0	6.2
	2010	40.1	7.0	10.0	42.0	5.0	7.0
Pruning at 1 m height of the branches emerging after limb pruning (decrowning) or top working twice in a year	2009	36.2	9.4	9.0	36.2	2.4	6.0
	2010	38.0	10.0	11.0	38.0	3.0	7.0
Treatment 1 and application of Paclobutrazol @ 4ml a.i./ tree/year	2009	7.8	28.2	8.6	5.1	38.0	10.0
	2010	8.2	32.0	6.0	7.0	40.0	7.0
Treatment and application of Paclobutrazol @ 8 ml a.i./ tree once in two years	2009	9.3	28.0	7.8	5.3	34.0	6.4
	2010	10.3	30.0	8.0	8.2	36.0	8.0
No further pruning after limb pruning (control)	2009	33.8	12.8	7.2	38.5	4.8	7.0
	2010	35.8	14.0	8.0	40.0	8.2	8.0

**Table 6.6: Effect of canopy management treatments on nut yield (kg/tree)**

Treatments	Top worked on VRI-1 (12 years old) with Bhaskara			Bhaskara (Seven years)		
	2009	2010	Mean	2009	2010	Mean
Pruning at 1 m height of the branches emerging after limb pruning (decrowning) or top working once in a year	1.51	3.85	2.68	1.01	1.50	1.25
Pruning at 1 m height of the branches emerging after limb pruning (decrowning) or top working twice in a year	1.75	4.20	2.97	1.03	1.25	1.14
Treatment 1 and application of Paclobutrazol @ 4 ml a.i./tree/ year	5.48	6.20	5.84	1.95	3.20	2.57
Treatment 1 and application of Paclobutrazol @ 8 ml a.i./tree once in two years	5.51	6.80	6.80	1.85	2.85	2.35
No further pruning after limb pruning (control)	4.00	3.5	3.50	2.75	2.10	2.43

### 6.3.5 Conclusions

The experiment was conducted on 12 years old existing high density cashew orchard by limb pruning for rejuvenation. Paclobutrazol application at a rate of 8 g *a.i./tree* once in two years reduced the growth and induced synchronized flowering. The tree height and canopy size was reduced to 50 per cent with shortened stem length and internodal length and more of branching compared to control. The nut yield (5.84 kg and 6.80 kg per tree) was higher in the trees treated with paclobutrazol as compared to other treatments tested in the study.

### 6.4 Geographical Information System (GIS) and Remote Sensing (RS) technologies to develop a spatial database and to identify suitable areas for expanding cashew cultivation - A study at Farm level

Project Leader : R. Rejani

Project Associates : N. Yadukumar (2007-2009)  
P.D. Sreekanth (2009-2011)  
M.G. Nayak (2010-2012)  
T.R. Rupa (2011-2012)

Project Duration : 2007-2012

#### 6.4.1 Introduction

At present, cashew is fast spreading even in non-traditional areas such as Gujarat, Jharkhand, North Eastern Hilly (NEH) Region, Andaman & Nicobar Islands, Chhatisgarh and Plains region of Karnataka. While selecting the new area, the suitability of the land plays an important role in achieving sustainable production. The productivity and growth of cashew plant in different parts of India shows that there is significant influence of soil type and climatic conditions on cashew crop. Hence this study was proposed to determine area under cashew and barren areas available using remote sensing and to find out the land suitability for cashew in India using Arc GIS.

#### 6.4.2 Objectives

- To prepare a spatial data base (meteorological data, altitude, land-use, soil characteristics, soil moisture content, nutrient content, cashew

yield etc.) using Geographical Information System.

- Identification and quantification of cashew area using Remote Sensing and assessing the applicability of RS in determining the seedling area and suitable areas for expanding cashew.

#### 6.4.3 Material and methods

Soil samples from two different depths (0-30 cm and 31-60 cm) were collected from different plots of Shanthigodu and were analyzed for soil moisture content and nutrient status and prepared the preliminary spatial data base using GRAM++ package. This spatial data base is essential for estimating the nutrient based budgeting for cashew orchards to reduce the inputs required. Collected other related data for the preparation of spatial data base such as altitude, land use, soil type, runoff and cashew yield *etc.* Prepared the spatial data base using GIS to aid the decision making process for the optimal water and nutrient management. Assessed the applicability of RS in determining the seedling area and other barren areas for expanding cashew. A decision support system has been developed using Visual Basic for estimating the NPK requirement of cashew based on the soil nutrient budgeting, age of cashew trees and tree density.

#### 6.4.4 Results and discussion

##### 6.4.4.1 Remote Sensing using Erdas Imagine

The IRS P6 LISS IV MX data with a spatial resolution of 5.8 m and LISS III data with a spatial resolution of 23.5 m procured from NRSC, Hyderabad was classified for determining the area under cashew, other vegetations, barren areas etc, have been done using Remote Sensing software, Erdas Imagine for an area of 20,000 ha (LISS IV) and 80,000 ha (LISS III), respectively. It was found that the images pertaining to the month of November is suitable for finding cashew since the colour of cashew leaves changes during that period. Among the LISS III and LISS IV images, the LISS III image was found to be suitable for classifying cashew vegetation since the error in classification of data is comparatively less (Fig. 6.2).

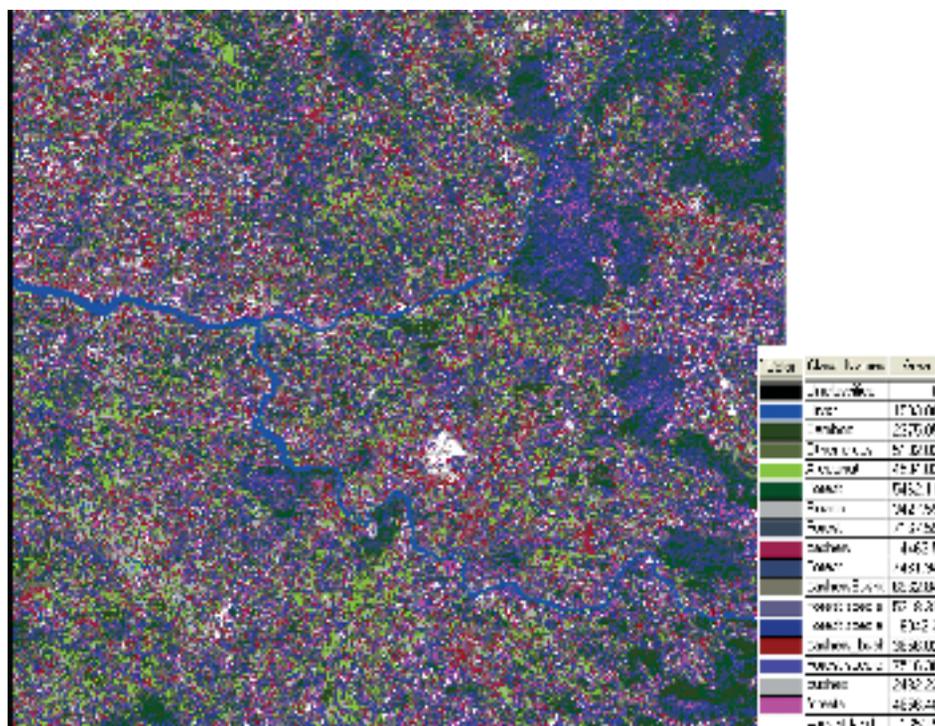


Fig.6.2: Image classification of LISS III images using ERDAS Imagine

#### 6.4.4.2 Development of a nutrient decision support system for rainfed cashew

A nutrient decision support system (NDSS) was developed for cashew using Visual Basic package for determining the site specific fertilizer and or manure requirement. This was developed based on the addition and removal of nutrients from the system (nutrient balance). The key principle included the estimation of nutrient requirement which depends on optimal yield, net profit, nutrient removal by trees, canopy biomass fallout, canopy wash N, P and K, initial and post soil N, P and K. Addition/deficit of N, P and K was estimated using the following equations (Richard, 1993).

$$N = N_i + N_{CB} + N_{AM} + N_{CW} - (N_p + N_{uptake}) \quad (1)$$

$$P_2O_5 = P_i + P_{CB} + P_{AM} + P_{CW} - (P_p + P_{uptake}) \quad (2)$$

$$K_2O = K_i + K_{CB} + K_{AM} + K_{CW} - (K_p + K_{uptake}) \quad (3)$$

where N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O are the nitrogen, phosphorus and potassium (addition/deficit), N<sub>i</sub>, P<sub>i</sub> and K<sub>i</sub> are the initial soil N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O, N<sub>CB</sub>, P<sub>CB</sub> and K<sub>CB</sub> are the canopy biomass N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O, N<sub>AM</sub>, P<sub>AM</sub> and K<sub>AM</sub> are the applied fertilizer N, P<sub>2</sub>O<sub>5</sub>

and K<sub>2</sub>O, N<sub>CW</sub>, P<sub>CW</sub> and K<sub>CW</sub> are the canopy wash N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O, N<sub>p</sub>, P<sub>p</sub> and K<sub>p</sub> are the post soil N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O. The quantity of inorganic fertilizers and or organic manures is also dependent on the composition of nutrients in it. In the present study, leaching is considered to be negligible since fertilizer application is done at the end of the rainy season. The optimal organic manure / inorganic fertilizer requirement for rainfed cashew has been estimated with varying plant density, age of the plant, initial and final soil test values of N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O.

The developed NDSS was validated for the optimal dose of fertilizers and manures determined (predicted values) with the measured values obtained from the field experiments (under high density and normal density planting systems). The results of validation could be evaluated by means of mean error (ME), mean absolute error (MAE) and root mean squared error (RMSE). In this study, ME and RMSE were used (Equations 4 and 5).

$$ME = \frac{1}{n} \sum_{i=1}^n (O - P)_i \quad (4)$$

$$RAMSE = \frac{1}{n} \sum_{i=1}^n [O - P]_i^2 \quad (5)$$

where, O = observed/measured optimal dose of fertilizer/manure (kg), P = predicted optimal dose (kg) and n = total number of observed/measured data. A linear regression analysis of the measured and predicted dose of fertilizers and manures were also done. The interpretations were made on the basis of suggested optimum level of N as 272 to 544 kg/ha, P as 12.4 to 22.4 kg/ha and K as 113 to 280 kg/ha.

#### **6.4.4.3 Optimal organic manure/inorganic fertilizer requirement for varying density and age of plant**

The optimal organic manure/inorganic fertilizer requirement for varying plant density and age was estimated. The requirement corresponding to sixth year shows that the fertilizer/manure requirement per plant reduced with increased plant density (Table 6.7). This was mainly due to the nutrient build up in the soil as a result of increased biomass fall out under high density planting system. The recommended dose of organic/inorganic manure requirement with N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O content of 160, 12 and 110 kg/ha/year (less fertile soil) in the 6<sup>th</sup> year with vigorous canopy type and optimal yield were 800 g urea, 312 g Rock Phosphate (RP), 105 g

Muriate of Potash (MOP) and 10 kg FYM respectively. In case of soil test based application, for less fertile soil it was 416 g urea, 135 g RP, 114 g MOP and 10 kg FYM and for medium fertile soil, it was 103 g urea, 131 g RP, 12 g MOP and 10 kg FYM. The recommended dose and optimal quantities of urea, RP and MOP corresponding to different ages of cashew plants under high, medium and normal density planting systems in case of low and medium fertile soils vary considerably (Table 6.8). Hence, the soil test based nutrient application using NDSS was very effective in cashew garden.

In case of organic cultivation with a choice for less quantity manure, the user can select poultry manure or cakes like castor cake, neem cake, groundnut cake, pongamia cake etc. In case of availability of other organic manures, the user can choose vermicompost, biomass compost, FYM or in combination with cakes. In case of inorganic cultivation the user can select urea, DAP and MOP with FYM or urea, RP and MOP with FYM. The developed NDSS was found to be feasible for determining the nutrient requirement in inorganic and/organic form for rainfed cashew garden grown along the West Coast region of India.

**Table 6.7: Optimal organic/inorganic manure requirement for varying plant density**

Source of fertilizer/manure		Plant density (D-plants/ha) corresponding to optimal yield (Y-kg/ha)							
		D=625 and Y=1251-1875		D=500 and Y=1150-1500		D=416 and Y=957-1248		D=200 and Y=500-600	
		Organic/inorganic manure requirement							
		kg/plant	kg/ha	kg/plant	kg/ha	kg/plant	kg/ha	kg/plant	kg/ha
Inorganic manure	Urea	0.39	245.8	0.42	209.0	0.47	195.0	0.64	127.6
	DAP	0.05	36.7	0.06	31.0	0.15	61.2	0.19	37.2
	MOP	0.11	71.5	0.11	54.0	0.10	41.5	0.05	10.5
	FYM	10.00	6250.0	10.00	5000.0	10.00	4160.0	10.00	2000.0
Inorganic manure	Urea	0.41	260.0	0.44	221.0	0.44	184.6	0.61	121.3
	RP	0.13	84.5	0.14	70.6	0.06	26.6	0.08	16.2
	MOP	0.11	71.5	0.11	53.5	0.10	41.5	0.05	10.5
	FYM	10.00	6250.0	10.00	5000.0	10.00	4160.0	10.00	2000.0
Compost	RCB+ 20% cow dung slurry	22.20	13881.2	23.20	11605.0	24.20	10075.3	30.70	6142.0
Vermicompost	Vermicompost	16.60	10410.0	17.40	8703.7	18.20	7556.5	23.00	4606.5
FYM	FYM	35.50	22210.0	37.10	18568.0	38.70	16120.5	49.10	9827.2
Poultry manure	Poultry manure alone	10.70	6663.0	11.10	5570.4	11.60	4836.0	14.70	2948.2
Neem cake	Neem cake alone	5.10	3203.0	5.30	2678.0	5.60	2325.0	7.09	1417.3
Neem cake + FYM	Neem cake	3.68	2301.9	3.90	1956.9	4.10	1725.0	5.60	1129.0
	FYM	10.00	6250.0	10.00	5000.0	10.00	4160.0	10.00	2000.0
Castor cake	Castor cake alone	4.70	2948.0	4.90	2465.0	5.10	2140.0	6.50	1304.4
Castor cake + FYM	Castor cake	3.40	2118.5	3.60	1801.0	3.80	1587.6	5.20	1039.0
	FYM	10.00	6250.0	10.00	5000.0	10.00	4160.0	10.00	2000.0
Pongamia cake	Pongamia cake alone	9.07	5668.0	8.70	4381.0	8.40	3516.0	9.30	1865.0
Pongamia cake + FYM	Pongamia cake	4.84	3030.3	5.10	2576.2	5.50	2271.0	7.40	1486.0
	FYM	10.00	6250.0	10.00	5000.0	10.00	4160.0	10.00	2000.0
Groundnut cake	Groundnut cake alone	5.90	3701.0	6.10	3094.0	6.50	2686.0	8.10	1637.0
Groundnut cake + FYM	Groundnut cake	4.20	2660.0	4.50	2261.3	4.80	1993.4	6.50	1304.5
	FYM	10.00	6250.0	10.00	5000.0	10.00	4160.0	10.00	2000.0

 (Note: Estimation with N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O as 160, 12 and 110 kg/ha/year, respectively in the sixth year with vigorous canopy type and optimal yield)

**Table 6.8: Optimal organic/inorganic manure requirement (kg/plant) corresponding to optimal yield and varying plant age**

Source of fertilizer/manure		Optimal organic/inorganic manure requirement corresponding to plant age (A-years) and optimal yield (Y-kg/ha)							
		A=1; Y= negligible	A=2; Y= 125-312	A=3; Y= 313- 500	A=4; Y= 501-625	A=5; Y= 626-1250	A=6; Y= 1251-1875	A=7; Y= 1876-1938	A=8; Y= 1939-2063
Inorganic manure	Urea	0.000	0.124	0.218	0.289	0.344	0.393	0.442	0.492
	DAP	0.000	0.000	0.012	0.038	0.049	0.058	0.068	0.077
	MOP	0.000	0.000	0.000	0.057	0.087	0.114	0.141	0.168
	FYM	8.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000
Inorganic manure	Urea	0.000	0.126	0.223	0.304	0.363	0.416	0.469	0.528
	RP	0.000	0.010	0.029	0.089	0.113	0.135	0.157	0.179
	MOP	0.000	0.000	0.000	0.057	0.087	0.114	0.141	0.168
	FYM	8.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000
Compost	RCB+ 20% cow dung slurry	5.000	11.000	14.800	17.900	20.100	22.200	24.200	26.200
Vermi-compost	Vermicompost	3.750	8.300	11.100	13.400	15.100	16.700	18.200	19.700
Farm Yard Manure (FYM)	FYM alone	8.000	17.700	23.700	28.600	32.200	35.500	38.700	42.000
Poultry manure	Poultry manure alone	2.400	5.300	7.100	8.500	9.680	10.700	11.600	12.600
Neem cake	Neem cake alone	1.150	2.500	3.400	4.100	4.600	5.100	5.600	6.000
Neem cake + FYM	Neem cake	0.000	1.100	1.970	2.700	3.200	3.700	4.150	4.200
	FYM	8.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000
Castor cake	Castor cake alone	1.060	2.300	3.100	3.800	4.200	4.700	5.100	5.600
	Castor cake +FYM	0.000	1.000	1.800	2.400	2.960	3.400	3.800	4.600
	FYM	8.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000
Pongamia cake	Pongamia cake alone	1.500	3.300	4.500	6.600	7.900	9.070	10.200	11.300
Pongamia cake+ FYM	Pongamia cake	0.000	1.460	2.600	3.500	4.200	4.800	5.400	6.000
	FYM	8.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000
Groundnut cake	Groundnut cake alone	1.300	2.900	3.900	4.800	5.300	5.900	6.500	7.000
Groundnut cake + FYM	Groundnut cake	0.000	1.280	2.280	3.100	3.700	4.300	4.800	5.300
	FYM	8.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000

(Note: Estimation with N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O as 160, 12 and 110 kg/ha/year, respectively with 625 plants/ha, vigorous canopy type and optimal yield)

#### 6.4.4.4 Soil moisture content

The soil moisture content at three different depths (0-30, 31-60 and 61-90 cm) were determined. During January and February 2008, the soil moisture content in the irrigated plots ranged from 19.8 to 22.7 per cent db. In the unirrigated plots, majority of the plots have soil moisture content in the upper layer (0-30 cm), ranged from 9 to 13 per cent db and soil moisture content in the lower layers (31-90 cm) ranged from 10 to 15 per cent db. In March, 2008, the soil samples were saturated after a rainfall of ~ 100 mm. The soil moisture content upto 90 cm depth from different plots were determined during December, 2009, January, 2010 and February, 2010 using TDR soil moisture profiling system. During February, 2010, in the irrigated plots of INM, the soil moisture ranged from 20 to 21 per cent db in the upper layer and 16.2 to 18.8 per cent db in the lower layer. In control plot without irrigation, it was 12 per cent db. During March, 2010, the soil moisture

content in the unirrigated plots reduced to 10.0 to 11.8 per cent db whereas, in irrigated plots, it was 19 to 21 per cent db (below the available soil moisture range). The soil moisture content during March, 2012 was significantly higher in drip irrigated plots (18.2 and 23.3 percent db). In control, it was very less (10.3 to 12.9 per cent db).

**Elevation:** The spatial data base of elevation of the DCR farm and surrounding area was prepared using Arc GIS software. The elevation data was collected using global positioning system (GPS). The topography of the farm (from elevation data of >1000 points) is undulating with an elevation varying from 41 to 145 m above MSL with a downward slope towards Kumaradhara river.

#### 6.4.4.5 Crop suitability studies

The distribution of cashew in India was prepared using Arc GIS (Fig.6.3).

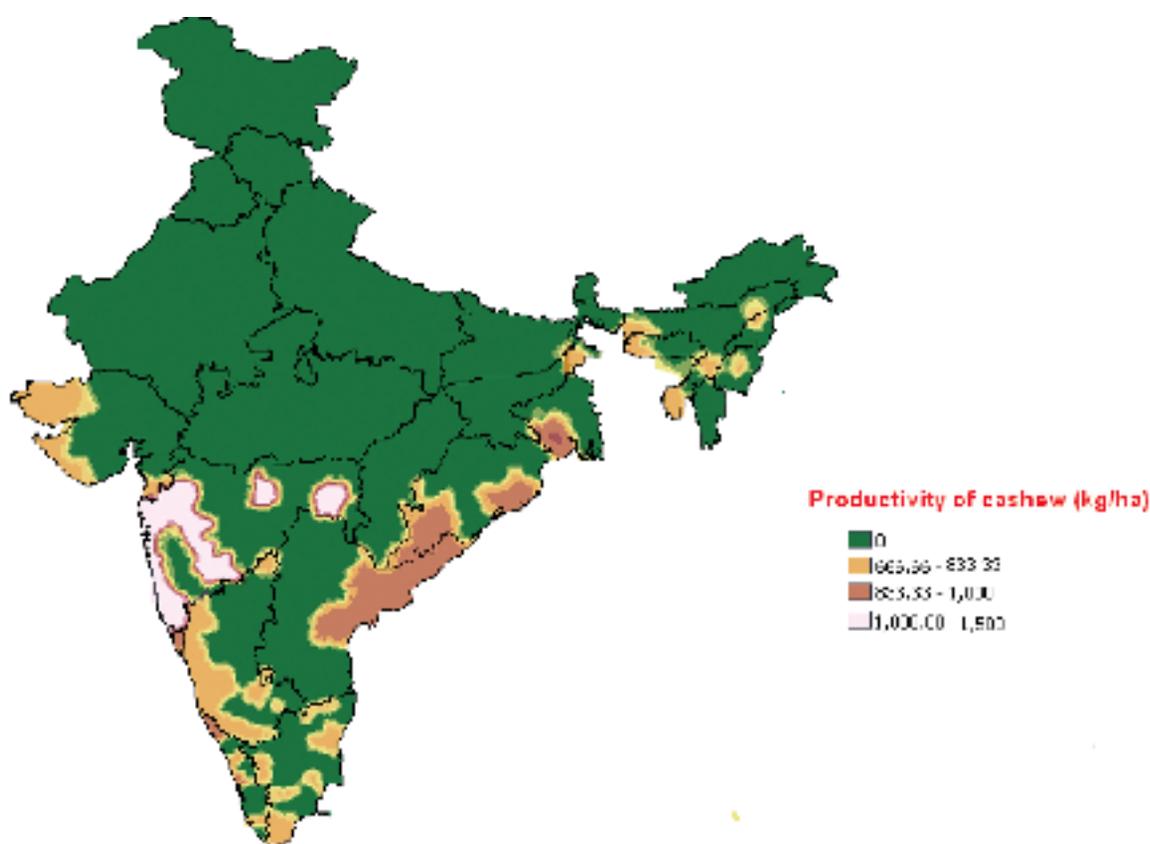


Fig. 6.3. Distribution of cashew area in India

The spatial data base of soil, cashew (survey data), surface elevation, mean annual rainfall, mean annual minimum temperature and mean annual temperature at country level was prepared using Arc GIS and its overlay with cashew area distribution was done for the crop suitability studies. It was found that cashew was distributed along loamy red and lateritic soil, mixed red and black soil, coastal and deltaic alluvium derived. The elevation of the cashew growing areas ranged from 0 to 1000 m above MSL and the productivity of cashew was higher in regions upto 750 m above MSL. It was observed that mean annual rainfall distribution in cashew area ranged from low rainfall (300-600 mm in Gujarat) to high rainfall (2700 to 3000 mm in West coast and NEH region). The productivity was highest in regions with a mean annual rainfall distribution of 600 to 1500 mm. The overlay maps showed that cashew was cultivated along regions where the mean annual temperature ranged from 20.0 to 27.5°C and the productivity was higher in regions where the mean annual temperature ranged from 22.5 to 27.5 °C. The productivity of cashew was higher in regions where the minimum temperature ranged from 10 to 22°C and was lower in regions where the minimum temperature drops below 10°C.

#### 6.4.5 Conclusions

A methodology was standardized to find out the area under cashew, barren areas and other non-traditional areas for expanding cashew cultivation using GIS and RS techniques. Classification of satellite imageries using remote sensing software ERDAS imagine showed that the images pertaining to the month of November is best for classifying cashew since the colour of cashew leaves changes during that period. The LISS III image was good for identifying cashew. It was not possible to differentiate the cashew seedling area and cashew graft area using LISS III or LISS IV images. A nutrient decision support system was developed for cashew using Visual Basic package for determining the site specific fertilizer and or manure requirement. The spatial data base of soil, cashew (survey data), surface elevation, mean annual rainfall, mean annual minimum temperature and mean annual temperature at country level was prepared using Arc GIS and its overlay

with cashew area distribution was done for the crop suitability studies. Cashew was generally distributed along loamy red and lateritic soil, mixed red and black soil, coastal and deltaic alluvium derived soil. The elevation of the cashew growing areas ranged from 0 to 1000 m above MSL and the productivity of cashew was higher in regions upto 750 m above MSL. It was observed that mean annual rainfall distribution in cashew area ranged from low rainfall (300-600 mm in Gujarat) to high rainfall (2700 to 3000 mm in west coast and NEH region). The productivity was highest in regions with a mean annual rainfall distribution of 600 to 1500 mm. The overlay maps showed that cashew is cultivated along regions where the mean annual temperature ranged from 20.0 to even more than 27.5°C and the productivity was higher in regions where the mean annual temperature ranged from 22.5 to 27.5 °C. The productivity of cashew was higher in regions where the minimum temperature ranged from 10 to 22°C and was lower in regions where the minimum temperature drops below 10°C.

#### 6.4.6 Publications

- Rejani, R. and Yadukumar, N. 2011. A nutrient decision support system for rainfed cashew. *Journal of Plantation Crops* 40(1): 40-49.
- Rupa, T.R., Rejani, R. and Bhat, M.G. 2012. Climate change effects on cashew and adaptation strategies. Proceedings of the National Dialogue on Climate Resilient Horticulture held on 28-29 January at IIHR, Bengaluru, pp.200-211.
- Rupa, T.R., Nayak, M.G., Adiga, J.D., Rejani, R. and Kalaivanan, D. 2011. Achievements of DCR in crop management of cashew. Souvenir, Silver Jubilee Celebrations (1986-2011) of DCR - National Expert Consultation on Cashew, December 23-24, pp. 17-19.
- Rupa, T.R., Bhat, M.G. and Rejani, R. 2011. Cashew production in relation to climate change. International conference on issues for climate change, land use diversification and biotechnological tools for livelihood security (October 8 to 10), Hi-Tech Horticultural Society, Meerut, pp. 43-46.

## 6.5 Nutrient requirement and pruning trials in high-density plantation

Project Leader : N Yadukumar (2000-2010)  
R. Rejani (2010-2012)

Project Duration : 2000-2012

### 6.5.1 Introduction

In high density planting system of cashew, the fertilizer recommended is reasonable upto 80-100 per cent canopy coverage which is normally achieved during the initial 6-8 years after planting. After certain stage of the crop, reduction in recommended dose of fertilizer / manure may be necessary due to the nutrient build up in the soil due to the deposit of cashew biomass fall out. Systematic information is not available on the optimal NPK requirement based on tree density and yield. Hence, the study was undertaken with the objective of determining the optimal nutrient requirement in cashew under different plant densities. The application of optimal fertilizer to the soil helps to reduce the input required, cost of cultivation and finally the ecological hazards arising due to inorganic fertilizer application.

### 6.5.2 Objective

To study nutrient requirements per unit area for three different plant densities.

### 6.5.3 Material and methods

The experiment was laid out in a split plot design with Ullal-3 variety in 2000 under three plant densities viz., 200 (S1), 416 (S2) and 500 (S3) plants/ha as main plot treatments and three fertilizer doses viz., 75 kg N, 25 kg each of  $P_2O_5$  and  $K_2O$  (M1), 150 kg N, 50 kg each of  $P_2O_5$  and  $K_2O$  (M2), 225 kg N, 75 kg each of  $P_2O_5$  and  $K_2O$ /ha (M3) as sub plot treatments with three replications. The data on growth, light interception by canopy and yield of the cashew were recorded. Economics was worked out for the first ten year period (2000-2010). The soil moisture content at three different depths (0-30, 31-60 and 61-90 cm) in different plant densities was determined at the base of the plant within 1m radius and in the middle of four plants using TDR soil moisture profiling system. The nutrient content of the soil corresponding to different fertilizer doses and plant densities was determined as per standard procedures. The yield of the cashew plants after thinning was recorded for a period of two more years.

## 6.5.4 Results and discussion

### 6.5.4.1 Effect of spacing and manure on growth, light interception by canopy and yield of cashew plants

Among different fertilizer doses, 75 kg N, 25 kg  $P_2O_5$  and 25 kg  $K_2O$ /ha was optimal for high density cashew orchards. Increasing dose of fertilizer increased the canopy coverage and yield of cashew for the first two harvest periods. For the third harvest onwards, it did not vary much (Tables 6.9 and 6.11).

Under high density planting system (S2 and S3), the ground coverage and light interception by the canopy were 92-98 per cent and 72-80 per cent, respectively compared to 55-60 per cent and 32-42 per cent in normal density planting system (S1) during 2008 (Tables 6.9 and 6.10). During 2007, in high density planting system, it was 70-83 per cent and 49-67 per cent, respectively, compared to 48-52 per cent and 14-20 per cent, respectively in control. The yield of cashew increased significantly in high density planting system (S2 and S3) over the years (Tables 6.9 and 6.11). During 2006-07 and 2007-08, the yield in high density plots was on par. Also, the canopy coverage was 94-96 per cent. Hence the plants in these treatments were detopped at 2.5 m height. Even though the yield in that particular year (2008-09) was relatively less, the yield in the subsequent year was increased.

During 2009-10, the yield under high density planting system (S2 and S3) was 12-25 per cent higher (2185 and 2430 kg/ha) than in normal planting system (1952 kg/ha) (Table 6.10). The higher cumulative nut yield (upto 10<sup>th</sup> year after planting) of 7.0 t/ha and 6.3 t/ha was obtained in high density planting system 500 and 416 plants/ha whereas in normal planting system it was only 5.2 t/ha (Table 6.12).

### 6.5.4.2 Economics

The highest cumulative net profit of ₹ 1,67,002/ha (25% more than control) for the first ten years (2001-2010) were obtained from the treatment of high density planting with lower dose of fertilizer (M1S3). The cumulative net profit from control (M1S1) was only ₹ 1,34,012/ha (Table 6.13).

**Table 6.9: Per cent ground coverage increase over years (2003-2008)**

Treatments	2003-04	2004-05	2005-06	2006-07	2007-08
S1M1	9.81	13.86	21.92	52.16	55.00
S1M2	11.44	24.11	21.43	50.42	58.00
S1M3	16.08	25.64	21.04	48.18	60.00
Mean S1	12.44	21.20	21.46	50.25	57.67
S2M1	15.79	27.80	40.49	70.30	92.00
S2M2	20.89	31.20	39.77	73.75	94.00
S2M3	27.52	34.00	39.69	72.80	95.00
Mean S2	21.40	31.00	39.98	72.28	93.67
S3M1	13.84	30.13	38.38	83.00	94.00
S3M2	22.56	27.20	55.33	83.40	96.00
S3M3	28.28	49.20	54.70	83.60	98.00
Mean S3	21.56	35.51	49.47	83.33	96.00
CD (p=0.05) (Plant density)	5.42	6.31	6.96	NS	3.85
Sub-effects (mean)					
M1	13.1	23.9	33.59	68.48	80.33
M2	18.3	34.1	38.81	69.05	82.66
M3	23.9	36.3	38.45	67.99	84.3
CD (p=0.05) (Fertilizer)	6.52	5.79	NS	NS	2.44

NS = Not significant

#### 6.5.4.3 Effect of high density planting system on moisture and nutrient content of soil

The soil moisture content under high density planting (S2 and S3), at the base of the plant during February and March, 2010 was higher in the lower layers (10 to 17.1 % dry basis) as compared to normal density planting system (S1) (9.1 to 11.4% dry basis). Similar trend was observed in the case of soil

moisture in the middle of four plants. Higher content of organic carbon was also recorded under higher density planting plots (S2 and S3) than in normal density planting (Table 6.14). No specific trend in P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O content with respect to plant density and fertilizer dose. The P<sub>2</sub>O<sub>5</sub> content ranged from 13.26 to 18.93 kg ha<sup>-1</sup> and K<sub>2</sub>O content ranged from 154.4 to 185.4 kg ha<sup>-1</sup>

**Table 6.10: Per cent light interception by canopy in the allotted area (2008)**

Treatment (Plants/ha)	MI	M2	M3	Mean
S1 - 200	32.0	38.0	42.0	37.3
S2 - 416	72.0	74.0	76.0	74.0
S3 - 500	78.0	79.0	80.0	79.0
Mean	60.6	63.6	66.0	
CD (p=0.05) (Main plot)				2.27
CD (p=0.05) (Sub plot)				1.49

**Table 6.11: Variation of cashew nut yield (kg/ha) with different fertilizer treatments and plant density (2003-2010)**

Treatments	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09*	2009-10
S1M1	154.4	111.2	558	493.6	626	1145	2352
S1M2	241.2	122.6	464	502.3	730	1174	1440
S1M3	300.4	180.4	458	539.3	800	1250	2064
Mean S1	232.0	138.0	493.3	511.7	718.6	1189.7	1952.0
S2M1	299.6	216.7	628	1129.6	1293	350	1699
S2M2	485.8	244.2	745	985.6	1077	390	2469
S2M3	615.7	319.1	807	1163.3	1029	520	2387
Mean S2	467.0	260.0	726.6	1092.8	1133.0	420.0	2185.0
S3M1	207.2	285.5	927	1259.3	1353	540	2615
S3M2	420.0	313.4	1251	1173.5	1000	610	2500
S3M3	482.4	362.5	1240	801.3	1007	620	2174
Mean S3	369.8	320.4	1139.3	1078.0	1120.0	590.0	2430.0
CD (p=0.05) (Plant density)	48.8	56.6	200.0	295.5	164.86	180.57	178.45
Sub effects (mean)							
M1	220.40	204.47	704.33	960.83	1090.67	678.33	2222.00
M2	382.33	226.73	820.00	887.13	935.67	724.67	2136.33
M3	466.17	287.33	835.00	834.63	945.33	796.67	2208.33
CD (p=0.05) (Fertilizer)	87.65	81.04	NS	NS	NS	NS	NS

NS = Not significant; \*Detopping done at 2.5 m height

**Table 6.12: Variation of cumulative cashew nut yield (kg/ha) with different fertilizer treatments and spacing (2003-2010)**

Treatment (Plants/ha)	M1	M2	M3	Mean	% of control
S1 - 200	5440	4674	5592	5235	100
S2 - 416	5616	6397	6841	6285	120
S3 - 500 Å	7187	7268	6687	7047	135
Mean	6081	6113	6373		
CD (p=0.05) (Main plot)				585.9	
CD (p=0.05) (Sub plot)				NS	

NS = Not significant

**Table 6.13: Cost of cultivation and net profit from various treatments (2000-2010) (₹)**

Labour cost	S1M1	S2M1	S3M1	S1M2	S2M2	S3M2	S1M3	S2M3	S3M3
Jungle clearance and weeding	20000	20000	20000	20000	20000	20000	20000	20000	20000
Canopy management	3333	13867	16640	3333	13867	16640	3333	13867	16640
Fertilizers	10000	10000	10000	20800	20800	20800	25000	25000	25000
Manuring	5000	5000	5000	10400	10400	10400	11240	11240	11240
Plant protection measures	3333	6933	8333	3333	6933	8333	3333	6933	8333
Making pits and terrace, planting and staking	8889	18489	22222	8889	18489	22222	8889	18489	22222
Picking nuts	8160	8424	10781	7011	9595	10902	8388	10262	10031
Nut yield	5440	5616	7187	4674	6397	7268	5592	6841	6687
Total labour cost	58715	82713	92976	73766	100084	109297	80183	105791	113466
Fertilizers	7494	7494	7494	14988	14988	14988	22482	22482	22482
Plant protection chemicals	9227	9227	9227	12794	12794	12794	15378	15378	15378
Total cost of cultivation	75436	99434	109697	101548	127866	137079	118043	143651	151326
Nut yield	5440	5616	7187	4674	6397	7268	5592	6841	6687
Income	209448	216212	276700	179953	246269	2798142	15296	263382	257457
Net profit	134012	116778	167002	78405	118403	142735	97253	119731	106131
Benefit cost ratio	1.78	1.17	1.52	0.77	0.93	1.04	0.82	0.83	0.70

**Table 6.14: Nutrient content of the soil in different treatment plots (0-60 cm)**

Treatment (Plants/ha)	MI	M2	M3	Mean
S1-200	0.49	0.51	0.55	0.52
S2-416	0.51	0.51	0.62	0.55
S3-500	0.56	0.55	0.63	0.58
Mean	0.52	0.52	0.60	
CD (p=0.05) (Main plot)				0.05
CD (p=0.05) (Sub plot)				NS

NS = Not significant

### 6.5.5 Conclusions

Increasing dose of fertiliser increased the canopy coverage and yield of cashew for the first two harvest periods. For the third harvest onwards, it did not vary much. There was a build up of major nutrients in the soil under high density planting system due to the increased biomass produced by more number of cashew plants. No significant difference in leaf nutrient content was observed in different treatments. The ground coverage and light interception by the canopy were also significantly higher under high density planting system (92-98 and 72-80 per cent, respectively) compared to normal density planting system (55-60 and 32-42 per cent, respectively) seven years after planting. The higher cumulative nut yield of 7.0 t ha<sup>-1</sup> and 6.3 t ha<sup>-1</sup> was obtained in high plant density plots of 500 and 416 plants/ha, respectively. Whereas, in normal density planting it was only 5.2 t ha<sup>-1</sup> (for the first six harvests). Of the various plant densities and fertilizer levels tested in this study, high density planting system (500 plants/ha) with lower fertilizer dose (75 kg N, 25 kg P<sub>2</sub>O<sub>5</sub> and 25 kg K<sub>2</sub>O/ha) was superior in terms of higher net profit (₹ 1,67,002 /ha).

### 6.5.6 Publications

Yadukumar, N., Rejani, R., Rupa, T.R. and Srividya, B.R. 2011. Optimal nutrient requirement and plant density for enhancing the cashew productivity. *Journal of Plantation Crops*, 30(1): 26-29.

Yadukumar, N., Rejani, R., Rupa, T.R. and Srividya, B.R. 2010. Optimal nutrient requirement and

plant density for enhancing the cashew productivity. Proceedings of the Plantation Crops Symposium (PLACROSYM XIX), 7-10 December, RRII, Kottayam, Kerala. Pp 136-137.

## 6.6 Design and Development of Dryer for Raw Cashewnuts

Project Leader : Dr. D. Balasubramanian

Project Duration : 2008-2011

### 6.6.1 Introduction

In certain cashew growing places like North Eastern Hilly regions, harvesting of cashewnuts coincides with monsoon rains, affecting its quality. Freshly harvested cashewnuts can be successfully preserved by reducing their moisture content to a level that will discourage the activities of microorganism from deteriorating them. Ohler (1966) reported that moisture content above 8.0 per cent (d.b) for in-shell cashewnut will result to deterioration. Hence, harvested cashewnuts either affected by rain or not, need to be stored in a dried condition holding moisture content <8 per cent level to prevent attack and deterioration. In this context, it is envisaged that developing a dryer either operated by electrical power or agricultural waste fired furnace for raw cashewnuts would resolve the problem to a greater extent.

### 6.6.2 Objectives

- To study drying kinetics of raw cashewnuts in solar and convective hot air drying system.
- Developing drying model based on the relationship between time and temperature during convective hot air drying.

- Design and development of electrical / agricultural waste fired furnace operated drying system for raw cashewnuts.
- Performance evaluation of artificial dryer for raw cashewnuts and prototype development.
- Data analysis and project documentation.

### 6.6.3 Material and methods

Initially drying of raw cashewnuts, in convective air oven was conducted to understand its diffusion characteristics. Exposing raw cashewnuts (artificially soaked in water for different duration – simulated situation of rain affected nuts) in hot air environment indicated the time temperature relationship of drying the nuts. Data collected during drying experiments was fitted in the existing models to determine drying constant and the resultant drying constant was used to design a convective air drying in the case of electric power or conduction drying system in the case of agricultural waste fired furnace as heat source. Initially a working model was developed to optimize various processing parameters related to drying of raw cashewnuts. After optimizing the parameters and incorporating required changes in the design, finally a bench model (Proto type) was developed and its performance was evaluated.

### 6.6.4 Results and discussion

#### 6.6.4.1 Preliminary studies on drying of raw cashewnuts

Preliminary studies were conducted with raw cashewnuts variety Bhaskara in convective air oven revealed that increase in air temperature decreases time required for drying. But it was observed that loss of volatile contents from raw cashewnuts beyond air temperature of 65°C. Moreover, kernels turned scorched (discolouration) when it was exposed to high temperature while drying. Time required to dry raw cashewnuts at air temperature of 65°C inside oven was in the range of 18 to 22 h whereas drying time under sun was in the range of 33 to 40 h.

#### 6.6.4.2 Survey report on assessment of problem in NEH region of India

Cashew growing areas in NEH regions viz., Assam, Meghalaya, Manipur and Tripura were

visited for twin objectives to understand the problem of coincidence of rain with harvest of cashewnuts and to study the production potential of raw cashewnuts and processing facility in the region. Cashew production in NEH viz., Assam (8.88%), Meghalaya (60.03%), Manipur (4.44%) and Tripura (26.26%) was around 11260 MT harvested from a total area of 13,987 ha. Late flowering led to coincidence of nut harvest with monsoon rains deteriorating the nut quality. Peak harvest was interrupted by torrential and incessant rainfall, affecting the quality of the nuts, fetching low price in the market. Good quality nuts which escape rain fetched around ₹ 27 to 30 per kg. About 21 cashew processing units following drum roasting *i.e.* Assam (13 Nos.), Meghalaya (5 Nos.) and Tripura (3 Nos.) constitute cashew processing sector in NEH region. Only 20 per cent of total production was consumed by these processing units and remaining is exported to either Odisha or West Bengal. Most of the processing units were operating with lower efficiency needs immediate attention.

#### 6.6.4.3 Diffusion behavior of soaked raw cashewnuts for the development of convective air drying system

Moisture absorption of various components of in-shell cashewnuts viz., whole nut, shell and kernel indicated that the moisture content of whole nuts and fractions of in-shell cashewnuts increased with increase in soaking period. Rate of infusion of moisture during soaking was higher in the initial period up to 6 h and its slope decreased irrespective of whole nuts or fractions. Moisture infusion was found to be higher for shell followed by whole nuts and kernel. It is clear that in-shell cashewnuts when exposed to natural rain, moisture infusion takes place at higher rate in the beginning and gradually reduces, but continues to absorb moisture even after 48 days. Therefore, moisture content of rain soaked cashewnuts need to be brought to safer level to improve its shelf life. Taking into account, the practice of harvesting nuts every day, initial moisture content of in-shell cashewnuts corresponding to 24 h of soaking *i.e.* 20.44 per cent (d.b) was considered in all the experiments. Data, thus collected through drying experiments was analyzed

to determine drying constant. A conceptual design of dryer, employing thin layer drying technique with air supply system operated by diesel powered generator / dual system considering non-availability / erratic electric power supply in cashew growing NEH regions was developed.

#### 6.6.4.4 Drying characteristics of raw cashewnuts

Freshly harvested in-shell cashewnuts (var. Ullal-3) were collected from the farm of Puttur. Cashewnuts thus collected were cleaned and segregated into small (<25mm), medium (25-30 mm) and large size (>30 mm) nuts based on its major axis dimensions. Moisture content of in-shell cashewnuts was determined in triplicates following standard toluene distillation method and average values on per cent dry basis was recorded. The drying experiments were conducted in a laboratory-scale forced convective air dryer and the schematic diagram of the dryer. The initial moisture content of small, medium and large size in-shell cashewnuts was 11.64, 16.69 and 17.69 per cent (d.b) respectively. It was observed that trend of the curves showed a falling rate period of drying throughout the drying process. The falling drying rate of drying depends essentially on the rate of diffusion of moisture from interior to the exterior surface of the product and also on moisture removal from the surface. The duration of each of the drying regimes depends on the initial moisture content and the safe storage moisture content for agricultural products. The rate of moisture removal during this period is mainly dependent on the surrounding conditions and only affected slightly by the nature of the product. The moisture content of in-shell cashewnut decreased very rapidly during first 30 min. of drying, in comparison to later part of drying owing to more availability of free moisture on the surface during initial period of drying.

Rate of removal of moisture was higher in the beginning and decreased with increase in drying time irrespective of dry air temperature, indicating removal of free moisture from various layers of in-shell cashewnuts. It was evident that the total time required for drying small, medium and large size in-shell cashewnut decreased from 240 to 100 min, 1040 to 430 min and 1450 to 460 min. respectively with

the increase in air temperature from 40 to 60°C. Total surface area available in the given mass of nuts sample for drying could be the contributing factor for the faster rate of drying with respect to size of the in-shell cashewnuts. The effect of drying air temperature on drying rate of small, medium and large in-shell cashewnut, the drying rate increased from  $2.54 \times 10^4$  to  $7.38 \times 10^4$ ,  $1.92 \times 10^4$  to  $6.23 \times 10^4$  and  $1.55 \times 10^4$  to  $3.96 \times 10^4$  g of water/min/g of the dry matter for large, medium and small size in-shell cashewnut, respectively with the increase in air temperature from 40°C to 60°C. Increasing the drying temperature expectedly promoted drying rates in all cases. Time required to reduce the moisture content of <8 per percent (d.b.), which was considered to be safe level moisture (Ohler, 1972) for long period storage was 100, 430 and 460 min. for small size and 240, 1150 and 1450 min. for large size in-shell cashewnuts exposed to air temperature of 40, 50 and 60°C, respectively.

#### 6.6.4.5 Design and development of dual mode dryer for raw cashewnuts

A dual mode dryer suitable for drying in-shell cashewnuts was developed at DCR, Puttur. Major components of the dryer are i) drying chamber; ii) heat exchanger and iii) aspirator assembly with electronic circuit. Drying chamber is cubical in shape having a total volume of 0.081 m<sup>3</sup> and provided with glass wool thermal insulation on all sides. It is designed to accommodate 20 numbers of wire mesh trays of size 0.30 m x 0.24 m and about 5 kg of in-shell cashewnuts can be loaded on each tray. Heating coils (2 sets) of capacity 3 kW are provided diagonally opposite inside the drying chamber. Two fans are also fitted inside the chamber adjacent to heating coil for the circulation of hot air generated and operated by 1/8 hp single phase electrical motor. A circular of inlet of 0.01 m D was provided at the rear bottom of the chamber to allow externally generated hot air into the drying region. An outlet of 0.01 m D was also provided on the back side at the top corner of the drying chamber to leave off humid air from the drying chamber to hot air generator through an aspirator. A thermocouple with electronic assemble was provided to control the temperature of hot air being circulated inside the drying chamber.

#### 6.6.4.6 Effect of source of hot air on drying characteristics of in-shell cashewnuts

It was observed that the reduction in moisture content of in-shell cashewnuts showed falling rate of drying throughout the drying period. When electrical power was used for generating hot air, average moisture content of nuts reduced to 17.04, 12.71, 8.53, 5.80 and 3.96 after every 1 h period of drying. But in the case of thermal power for generating hot air, moisture level of the nuts reduced to 17.29, 13.21, 8.32, 6.62 and 5.64 for the same period of drying. It clearly indicates that loss of moisture from in-shell cashewnuts was faster in the case of electrical than thermal power. Falling rate period of drying is observed during drying of in-shell cashewnuts in dual mode dryer and a total time required to decrease the moisture content from 20.44 per cent d.b to safer level is in the range of 2.84 to 4.35 h for electrical power and 3.67 to 4.54 h for thermal power irrespective of size or location of nuts.

#### 6.6.4.7 Effect of size of in-shell cashewnuts on its drying characteristics

On an average, time required to reduce the moisture content of in-shell cashewnuts of small, medium and large size to safer level was worked out to be 4.41, 4.37 and 3.16 h in the case of electric power and 4.38, 4.28 and 4.11 h for thermal power, respectively. It was inferred that time taken for drying large size nuts was lesser than smaller size nuts. Although surface area increased in the case of smaller nuts as quantity of nut sample spread on the wire mesh for drying remained same in all experiments, number of large size nuts was lesser compared to small size nuts for the given mass. In addition, more void space in larger size nuts allowed hot air movement all over the surface and enhanced drying rate.

#### 6.6.4.8 Effect of position of nuts placed inside the dryer on drying characteristics

The uniformity in drying operation, moisture loss in in-shell cashewnuts placed in different locations *viz.*, top, middle and bottom tray were

analyzed. Differential rate of drying was recorded upto 4 h of drying and later it became non-significant. In the case of thermal power supplied by biofuel, hot air generated was allowed to enter at the bottom of the drying chamber and up-drafted. Hot air, thus lifted was aspirated by the fan provided in the opposite side and pushed downside, not allowing to pass through exit. As the hot air takes the immediate path of top trays and other location afterwards or passing out for recirculation, moisture loss was faster in the tray located at the top position followed by middle and bottom positions.

#### 6.6.4.9 Energy consumption during drying using dual mode dryer

Total energy required to dry in-shell cashewnuts from an initial moisture content of 20.44 to 8.00 per cent d.b was worked out to be in the range of 26.06 to 39.79 MJ for electrical system and 173.24 to 230.12 MJ in the case of cashew shell cake as bio fuel for generating thermal power. Cost of drying in-shell cashewnuts using dual mode dryer was worked out to be ₹ 0.44 per kg.

#### 6.6.5 Conclusions

A dual mode dryer which could be operated by utilizing either electrical or thermal power or both was developed for in-shell cashewnuts to preserve its quality. Falling rate period of drying was observed during drying of raw cashewnuts in the developed dryer and a total time required to decrease the moisture content from 20.44 per cent d.b to safer level is in the range of 2.84 to 4.54 h irrespective of the power used and size or location of nuts. Nut count in the given mass was the due reason for the variation in drying time with respect to size of the nuts. Differential rate of drying was recorded at selected locations of the drying chamber, but it became non-significant after 4 h of drying period irrespective of source of power utilized for generation of hot air. Energy utilized during drying operation to reduce moisture to safe level on an average was worked out to be 32.93 MJ for electrical power and 201.71 MJ for thermal power.

## 6.7 Studies on alternate energy utilization of cashew shell cake

Project Leader	: Dr. D. Balasubramanian
Project Associate	: Dr.Sandeep Gangil, CIAE, Bhopal
Project Duration	: 2008-2011

### 6.7.1 Introduction

It is estimated that presently used oil expellers could extract 28 per cent of cashewnut shell liquid (CNSL) from the shells, a huge quantity of 4.58 lakh MT of cashew shell cake is generated in the last fiscal year. Only 1/8<sup>th</sup> of the generated cashew shell cake available in the industries are utilised for the purpose of steam generation for nut conditioning process and hot air for kernel drying system. Remaining quantity of cashew shell cake either unutilized or transported to brick/kiln/ceramic industries in the neighbouring state for generating thermal energy. Storage of these cashew shell cake or transporting in loose form has become one of the greatest problems. Moreover, this huge quantity of shell cake produced in India is used inefficiently causing extensive pollution to the environment.

### 6.7.2 Objectives

- To determine physical and thermal properties of cashew shell cake for gasification.
- To adopt the briquetting technology for the production of briquettes from cashew shell cake.
- To optimise gasification parameters for cashew shell cake and its briquettes for thermal application.
- To assess techno-economic feasibility of briquetting and gasification of cashew shell cake.

### 6.7.3 Materials and methods

**Determination of moisture content and proximate analysis:** Initial moisture content of cashew shell and cashew shell cake (with residual CNSL) was determined using toluene distillation method. Proximate analysis was carried out to find out the ash, volatile and fixed carbon present in the raw materials to be used in the gasification process.

**Thermo-gravimetric analysis:** A thermo-gravimetric analyzer was used to determine the weight loss at different temperatures.

**Densification of cashew shell cake:** A mechanical pulveriser (hammer mill) was used to convert cashew shell cake into 2-3 mm size and used in briquette making process. Ram type briquette making machine (60 and 90 mm  $\phi$ ) was used for the densification of cashew shell cake along with saw dust mixture in the ratio of 30:70 and 50:50. Carbonization of cashew shell cake was attempted in an anaerobic condition, by taking a definite quantity of material (say 235 g) in a cylindrical container made out of galvanized iron with a 2mm  $\phi$  (ID) GI pipe welded to its side and totally covering top side. Cylindrical body with cashew shell cake was heated up (pyrolysis process) to allow moisture and volatile components to escape the material and converted in to carbonized cashew shell cake.

**Gasification of cashew shell cake and performance trials:** Cashew shell cake was loaded in the up draft gasifier completely and ignited through ignition port provided at the bottom. When smoke emanated from top layer of the shell cake which was loaded in the gasifier, gasifier was closed with lid after filling water in the annular space to avoid leakage of producer gas through lid. Blower was operated and velocity of air was maintained at 7 kg cm<sup>2</sup>. Producer gas generated from cashew shell cake passed through conduit and reached the burner. Burner was lit and flame temperature was measured using digital non contact thermometer. Time taken for complete gasification process was also noted. Trials were conducted to assess the performance of the gasifier for varied initial moisture content of cashew shell cake (3.74, 6.54 and 9.35 % d.b), air velocity (3.5 and 7.0 kg cm<sup>2</sup>) and quantity feed stock (3.5 to 14 kg) in terms of average flame temperature and burning period.

### 6.7.4 Results and disussion

#### 6.7.4.1 Determination of moisture content of cashew shell and its cake

The moisture content of shell and its cake were in the range of 2 to 3 percent d.b. (Table 6.15) which was considered to be sufficient to take up the trials on both gasification and densification processes.

**Table 6.15: Moisture content of cashewnut shell and its cake**

	Sample wt (g)	Volume of water (ml)	Moisture content (w.b) (%)	Moisture content (d.b) (%)
<b>Cashew shell cake</b>				
1	25.03	0.75	2.99	3.08
2	25.32	0.75	2.96	3.05
3	25.13	0.75	2.98	3.07
			Average	3.07
<b>Cashew shell</b>				
1	25.02	0.50	2.00	2.01
2	25.00	0.45	1.80	1.83
3	25.13	0.52	2.07	2.11
			Average	1.98

#### 6.7.4.2 Proximate analysis of cashew shell and its cake

Proximate analysis was carried out to find out the ash, volatile and fixed carbon present in the raw materials to be used in the gasification process. Completely dried cashew shell and its cake were exposed to high temperature i.e. 550°C for 30 min. to determine its ash and volatile content. High value for fixed carbon is the indication for better production of carbon monoxide from the selected raw material.

Accordingly, various samples were analysed for ash and volatile content and presented (Table 6.16). Average values of ash, volatile and fixed carbon were determined as 7.8 per cent, 19.9 per cent and 70.6 per cent, respectively for cashew shell and 13.3 per cent, 26.0 per cent and 57.4 per cent, respectively for cashew shell cake. Data generated in the proximate analysis clearly indicated that producer gas could be generated from cashew shell cake.

**Table 6.16: Proximate analysis of cashew shell and its cake**

Sl. No.	Sample wt (g)	Ash content (%)	Sample wt (g)	Volatile content (%)	Fixed carbon (%)
Cashew shell cake			Ave. MC 3% d.b		
1	5.06	13.0	4.99	24.0	60.0
2	5.07	13.2	5.05	26.0	57.8
3	5.04	13.6	5.06	26.0	57.4
	Average	13.3	5.03	25.3	59.4
Cashew shell			Ave. MC 2% d.b		
1	4.96	7.05	5.06	19.96	71.0
2	5.02	7.31	5.01	18.73	72.0
3	4.98	9.03	5.02	21.10	68.8
	Average	7.79	5.03	19.93	70.6

### 6.7.4.3 Determination of calorific value and producer gas of cashew shell and its cake

Average calorific values of cashew shell and its cake with moisture content in the range of 2 to 3 per cent d.b., were determined to be 5810 cal g<sup>-1</sup> and 4403 cal g<sup>-1</sup>, respectively using bomb calorimeter

(Table 6.17). In order to find out the quantity of producer gas that could be generated from cashew shell and its cake, Green's apparatus was used. Gas generated from cashew shell and its cake was found to be on an average of 501.17 cm<sup>3</sup> g<sup>-1</sup> and 490.96 cm<sup>3</sup> g<sup>-1</sup>, respectively (Table 6.18).

**Table 6.17: Calorific value of cashewnut shell and its cake**

	Stirrer temp. (°C)	Firing temp. (°C)		Time taken (Sec.)	Calorific value (Cal g <sup>-1</sup> )
		Initial	Final		
<b>Cashew shell cake</b>					
1	33.97	35.10	35.86	6.0	4403
2	34.01	35.06	35.92	6.0	4450
3	33.89	35.25	35.76	6.0	4357
				Average	4403
<b>Cashew shell</b>					
1	32.44	34.11	34.96	6.0	5965
2	32.65	34.90	35.08	6.0	5662
3	32.60	34.52	35.09	6.0	5802
				Average	5810
<b>Cashew shell cake (Pulverized) – Pellets</b>					
1	32.76	34.01	34.84	7.0	4366
2	30.01	31.42	32.24	7.0	5196
3	31.70	31.40	33.73	7.0	4730
				Average	4764

**Table 6.18: Producer gas generation using GREEN'S apparatus**

	Empty wt of wire mesh (g)	Wt of wire mesh + sample (g)	Sample wt (g)	Gas production (cm <sup>3</sup> )		Ash content (%)
				per sample	per unit weight	
<b>Cashew shell cake</b>						
1	6.31	9.93	3.62	1630	450	0.24
2	6.30	9.61	3.31	1580	477	0.20
3	6.22	9.38	3.16	1350	427	0.17
<b>Cashew shell</b>						
1	6.24	10.51	4.27	2140	501	0.26
2	6.09	10.28	4.19	2120	506	0.24
3	6.57	10.84	4.27	1900	445	0.23

#### 6.7.4.4 Thermo gram analysis of cashew shell cake

Thermo gram analysis showed four distinct segments. Comparison of thermo gram at different heating rates it was observed that the moisture removal process last up to 105°C and the release of lighter volatile initiated in the range of 120 to 250°C. There was lag of 40°C between initiation of cellulosic and hemi-cellulosic decomposition from lowest HR of 10°C /min and highest HR of 100°C /min. The lighter volatiles were noticed in the range of 44-52 per cent. There was better smoothening of thermo gram at higher HR at the point of transition phase of moisture removal and lighter volatile release indicating the larger overlapping of these two events at higher HR.

#### 6.7.4.5 Preparation of fuel briquettes (Densification) using cashew shell cake

Biomass briquetting is the process of converting low bulk density biomass into high density and energy concentrated fuel briquettes. Briquettes are good substitute of coal / wood in industrial boiler and brick kiln for thermal application. Initial trials were conducted with screw extruder available at M/s. Sree Engineering Company, Hyderabad to make briquettes from cashew shell cake. Due to the presence of oil content *i.e.* residual oil after expelling CNSL from cashew shell (Steam treated) and thickness of cake which ranges from 2 to 20 mm, compression could not be achieved in the screw press. Later on, cashew shell



Cashew shell cake based fuel briquettes (90 mm  $\phi$  size)

cake (pulverized) and saw dust were mixed in the ratio of 30:70 and 50:50 and fed in the screw extruder. Briquette could be formed with 30:70 ratios, but due to the presence of heating element in the densification zone, fumes generated. In the case of 50:50 mixture, screw was choked and whole operation stopped, indicating more oil content in the material reduces degree of compression inside briquette chamber owing to less internal friction between the surface of the mixture and inner face of the chamber.

Trials conducted with ram type briquette making machine (60 mm  $\phi$  and 90 mm  $\phi$  size) revealed that briquettes could be made using cashew shell cake (pulverized) and saw dust due to higher impact force *i.e.* 1200 kg cm<sup>-2</sup>, but developed cracks at disc joints of the briquettes. Particle size of cashew shell cake, moisture content of saw dust, feed rate, stroke length and oil content of mixture are the principal reasons for the formation of briquettes and its stability.

Carbonization of cashew shell cake was attempted in an anaerobic condition, by taking a definite quantity of material in a cylindrical container made out of galvanized iron with a 2 mm  $\phi$  (ID) GI pipe welded to its side and totally covering top side. Cylindrical body with cashew shell cake was heated up (pyrolysis process) to allow moisture and volatile components to escape the material and converted in to carbonized cashew shell cake. Taking in to account, the brittleness of carbonized cashew shell cake and composition *i.e.* carbon %, it could be confirmed that carbonized briquette could be made out of the carbonized material using roller press.

These results indicate that cashew obtained from drum roasting process (partially burnt shall) can be carbonized completely by retort process and converted into carbonized briquette for value addition to cashew byproduct. On the other hand, cashew shell cake obtained from steam boiling process can be utilized to prepare fuel briquettes using either screw extrusion or ram type briquette machines.

#### 6.7.4.6 Generation of producer gas (Gasification) using cashew shell cake

A cashew shell cake (CSC) based up draft gasifier was developed and its performance was evaluated. The CSC was gasified in updraft gasifier and consistent gasification was observed. The gasifier was tested for 70 h continuously and the biomass consumption was found to be 8-10 kg h<sup>-1</sup>. The time



**Generation of producer gas using cashew shell cake**

of start of gasifier was observed to be 15-20 min. at 1<sup>st</sup> ignition. After each intermittent feeding, the gas can be quickly obtained within 2-3 min. Even at the start gasifier on the next working day, the flame ignition was observed well within 5 min. The intermittent feeding period for operation of gasifier was computed to be 50-55 min. Various parameters influencing the gasification process such as velocity of inlet air, quantity of feed stock and moisture content of CSC were analyzed in terms of burning time and flame temperature. The flame temperature varied from 387 to 528°C with average mean value of 487°C. The tar generation with CSC

was observed to be high and deposited in the gas conduit with the progressive run of the gasifier. Gasification rate was computed as 116 kg h<sup>-1</sup> m<sup>-2</sup>. Protocol for operating gasifier with CSC was developed. The gasifier tested with CSC is suitable for applications needing thermal requirement of 10-12 kW.

#### 6.7.5 Conclusions

Proximate analysis of cashew shell cake indicated that average values of ash, volatile and fixed carbon were determined as 7.8 per cent, 19.9 per cent and 70.6 per cent respectively for cashew shell and 13.3 per cent, 26.0 per cent and 57.4 per cent, respectively. Average calorific values of cashew shell and its cake with moisture content in the range of 2 to 3 per cent d.b., were determined to be 5810 Cal g<sup>-1</sup> and 4403 Cal g<sup>-1</sup>, respectively using bomb calorimeter. Cashew shell cake obtained from drum roasting process (partially burnt shall) can be carbonized completely by retort process and converted in to carbonized briquette for value addition to cashew byproduct. On the other hand, cashew shell cake obtained from steam boiling process can be utilized to prepare fuel briquettes using either screw extrusion or ram type briquette machines. A cashew shell cake (CSC) based up draft gasifier suitable for applications needing thermal requirement of 10-12 kW was developed. Various parameters influencing the gasification process such as velocity of inlet air, quantity of feed stock and moisture content of CSC were analyzed in terms of burning time and flame temperature. Average flame temperature of gas generated was found to be 487°C and protocol for operating gasifier with CSC was developed.

**EDUCATION /  
TRAINING /  
GENERAL /  
MISCELLANEOUS  
INFORMATION**

## 7. EDUCATION AND TRAINING

- A National Cashew Stakeholders Meet was organized on 23 December, 2011 at DCR, Puttur in which representatives from cashew processors, development departments, scientists and cashew farmers participated.
- Agricultural Education Day-2012 was organized on 28 February, 2012 at DCR, Puttur in which 125 students from various schools of Puttur participated. The children were given exposure on the importance of Agricultural Education and the opportunities that are available in this area.
- A special training programme on soft wood grafting technique in cashew was organized during 16-17 March, 2012 for 10 participants from Goa Forest Development Corporation, Goa. The latest developments in soft wood grafting technique in cashew were explained to the trainees during the training programme.

## 8. LINKAGES / COLLABORATION

Name of the organization	Type of collaboration
Indian Institute of Horticultural Research (IIHR), Bengaluru	Biosystematics of tea mosquito bug.
National Bureau of Agriculturally Important Insects (NBAII), Bengaluru	Identification of kairomones / pheromones of major pests of cashew / Biosystematics of pests of cashew.
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 assistance for demonstration plots.
National Bank for Agriculture and Rural Development (NABARD), Mumbai	Annual Cashew Day.
Cashew Export Promotion Council of India (CEPCI), Kollam	Insecticide residue analysis. NAIP Project on "A value chain in cashew for domestic and export market".

Department of Horticulture, Karnataka Horticultural Research Station, Ullal, Mangalore. Zonal Agricultural Research Station, Brahmavar, Udupi district, Karnataka	}	Farmers training programmes, Krishi Mela.
KVK, Mangalore		Transfer of technology .
AICRP-Cashew Centres		Exchange of research findings / germplasm / planting material.
BAIF, Pune		Technical advice for improving the productivity of cashew plantations.

## 9. AICRP - CASHEW CENTRES

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### Co-operating Centres

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## 10. PUBLICATIONS

### 10.1 Research publications

Asokan, R., Rebijith, K.B., Krishnakumar, N.K., Srikumar, K.K., Bhat, P.S. and Ramamurthy, V.V. 2011. Molecular identification and diversity of *Helopeltis antonii* and *Helopeltis theivora* (Heteroptera:Miridae) in India. *Florida Entomologist*. 95: 349-357.

Asokan, R., Rebijith, K.B., Krishnakumar, N.K., Srikumar, K.K. and Bhat, P.S. 2011. Development of DNA barcode and species specific markers *Helopeltis antonii* Signoret and *Pachypeltis maesarum* (Kirkaldy) (Heteroptera: Miridae) pests of cashew in India. *Entomological News*. 122(2): 172-181.

Balasubramanian, D. and Sandeep, T.N. 2011. Performance evaluation of dual mode dryer for raw cashewnuts. *Journal of Plantation Crops*. 40(1): 28-34.

Balasubramanian, D. and Sandeep, T.N. 2011. Thin layer drying characteristics of in-shell cashewnuts using convective dryer. *Journal of Plantation Crops*. 39(1): 252-255.

Ramalakshmi., Suchita Naik., Balasimha, D. and Nayak, M.G. 2011. Photosynthetic characteristics in cashew cultivars. *Journal of Plantation Crops*. 39(1): 210-212.

Rupa, T.R., Yadukumar, N., Vidya, B.R. and Indushree, 2012. Effect of biofertilizers on growth of cashew rootstocks and soil microbial activity. *Cashew News*, July-December, 2011, Vol. 16(2): 5-6.

Srikumar, K.K. and Bhat, P.S. 2011. Comparison of the developmental and survival rates adult longevity and fecundity of *Helopeltis antonii* Signoret (Hemiptera: Miridae) on different phenological stages of cashew. *Journal of Plantation Crops*. 39(3): 347-350.

Srinivasan, R., Natarajan, A., Anil Kumar, K.S. and Kalaivanan, D. 2011. Land suitability evaluation of soils of Dakshina Kannada District of Karnataka for cashew production. *Journal of Plantation Crops*. 39 (2): 325-329.

Yadukumar, N., Rejani, R., Rupa, T.R. and Srividya, B.R. 2011. Optimal nutrient requirement and plant density for enhancing the cashew productivity. *Journal of Plantation Crops*. 30(1): 26-29.

## 10.2 Papers presented in symposia / workshop / seminar

Bhat, M.G. 2012. Organic Farming: Prospects and Problems. Presented as Presidential Address in the State Level Workshop on “Challenges of Crops Health Management in Organic Farming” held in College of Agriculture (KAU), Padannakkad, Kasaragod Dist., Kerala on 5 January, 2012.

Bhat, M.G. and Adiga, J.D. 2011. Breeding approaches for improvement of cashew. Presented in National Expert Consultation on Cashew. Silver Jubilee Celebrations (1986-2011) of Directorate of Cashew Research, Puttur during 23-24 December, 2011.

Balasubramanian, D. and Sandeep, T.N. 2011. Performance evaluation of dual mode dryer. In: 1<sup>st</sup> International Symposium on Cashewnut, Agricultural College and Research Institute, Madurai, Tamil Nadu, India. 9-12 December, 2011.

Bhat, P.S. and Raviprasad, T.N. 2011. IPM strategy for insect pest management of cashew. Presented in National Expert Consultation on Cashew of Directorate of Cashew Research, Puttur during 23-24 December, 2011 at DCR, Puttur.

Bhat P.S. and Raviprasad, T.N. 2011. Management of tea mosquito bug and cashew stem and root borers in cashew – presented in Workshop on Good Agricultural Practices for Cashew held at ICAR Research Complex for Goa on 23 July, 2011.

Nayak, M.G. 2011. Cashew varieties and their package of recommendations – presented in Workshop on Good Agricultural Practices for Cashew held at ICAR Res. Complex for Goa on 23 July, 2011.

Nayak, M.G. 2011. Cashew germplasm conservation and utilization efforts. Presented in National Expert Consultation on Cashew. Silver Jubilee Celebrations (1986-2011) of Directorate of Cashew Research, Puttur during 23-24 December, 2011.

Nayak, M.G. 2011. Recent advances in canopy architecture management in cashew. Presented in National Expert Consultation on Cashew. Silver Jubilee Celebrations (1986-2011) of Directorate of Cashew Research, Puttur during 23-24 December, 2011.

Raviprasad, T.N. 2011. Management Techniques for Cashew Stem and Root Borers (in Kannada). In Proceedings of the State level seminar on Cashew held at College of Horticulture, Kolar on 19 October, 2011.

Rupa, T.R., Bhat, M.G. and Rejani, R. 2011. Cashew production in relation to climate change. Souvenir (Eds: Dr. Bijendra Singh *et al.*), International Conference on Issues for Climate Change, Land Use Diversification and Biotechnological Tools for Livelihood Security (ICLDBT-2011), 8 October, 2011, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut (U.P.), India. Pp 43-52.

Rupa, T.R., Rejani, R. and Bhat, M.G. 2012. Climate change effects on cashew and adaptation strategies. Adaptation and Mitigation Strategies for Climate Resilient Horticulture (Eds: Dr. K.S. Shivashankara, Dr. Prakash Patil, Dr. G. Selvakumar and Dr. V. Sridhar). Published on the occasion of National Dialogue on Climate Resilient Horticulture held during 28-29 January, 2012 at Indian Institute of Horticultural Research, Bengaluru. Pp 200-211.

Srinivasan, R., Natarajan, A. and Kalaivanan, D. 2011. Characterization and classification of major cashew growing soils of Southern Karnataka using remote sensing technique. In: 1<sup>st</sup> International Symposium on Cashewnut, Agricultural College and Research Institute, Madurai, Tamil Nadu, 9-12 December 2011. Pp 108.

Yadukumar, N. and Rupa, T.R. 2011. Organic farming: Approaches and possibilities in cashew. Presented in National Expert Consultation on

Cashew. Silver Jubilee Celebrations (1986-2011) of Directorate of Cashew Research, Puttur during 23-24 December, 2011.

### 10.3 Books

Bhat, P.S., Vanitha, K. and Sajeev M.V. 2011 (Eds.). Souvenir on Silver Jubilee Celebrations and National Expert Consultation on Cashew. Directorate of Cashew Research, Puttur, Karnataka, India. 23-24 December, 2011.

#### 10.3.1 Book chapters

Bhat, M.G., Yadukumar, N., Nagaraja, K.V. and Nayak, M.G. 2012. Cashew Research and Technology Status in India. In Cashew Development in India Challenges and Opportunities (Editors: Dr. Gorakh Singh and V.N. Hubballi). Directorate of Cashewnut and Cocoa Development, GOI, Kochi. Pp 17-30.

Bhat, M.G. 2011. History of Cashew Research in India and Establishment of Directorate of Cashew Research and AICRP on Cashew. Souvenir on Silver Jubilee Celebrations (1986-2011) and National Expert Consultation on Cashew. Directorate of Cashew Research, Puttur, Karnataka, India. 23-24 December, 2011. Pp10-11.

Balasubramanian, D. 2011. Achievements of DCR in Processing of Cashew. Souvenir on Silver Jubilee Celebrations (1986-2011) and National Expert Consultation on Cashew. Directorate of Cashew Research, Puttur, Karnataka, India. 23-24 December, 2011. Pp 27-30.

Nagaraja, K.V. 2011. Achievements of DCR in Quality Aspects of Cashew, Souvenir on Silver Jubilee Celebrations (1986-2011) and National Expert Consultation on Cashew. Directorate of Cashew Research, Puttur, Karnataka, India. 23-24 December, 2011. Pp 24-26.

Nayak, M.G. and Sajeev M.V. 2011. Achievements of DCR in Transfer of Technology of Cashew. Souvenir on Silver Jubilee Celebrations (1986-2011) and National Expert Consultation on Cashew. Directorate of Cashew Research, Puttur, Karnataka, India. 23-24 December, 2011. Pp 31-34.

Rupa, T.R., Nayak, M.G., Adiga, J.D., Rejani, R. and Kalavanan, D. 2011. Achievement of DCR in Crop

Management of Cashew. Souvenir on Silver Jubilee Celebrations (1986-2011) and National Expert Consultation on Cashew. Directorate of Cashew Research, Puttur, Karnataka, India. 23-24 December, 2011. Pp17-19.

Sundararaju, D., Bhat, P.S., Raviprasad, T.N. and Vanitha, K. 2011. Achievement of DCR in Crop Protection of Cashew. Souvenir on Silver Jubilee Celebrations (1986-2011) and National Expert Consultation on Cashew. Directorate of Cashew Research, Puttur, Karnataka, India. 23-24 December, 2011. Pp 20-23.

Thimmappaiah, Nayak, M.G. and Adiga, J.D. Achievements of DCR in Crop Improvement of Cashew. Souvenir on Silver Jubilee Celebrations (1986-2011) and National Expert Consultation on Cashew. Directorate of Cashew Research, Puttur, Karnataka, India. 23-24 December, 2011. Pp12-16.

### 10.4 Technical reports / compendia / articles

Directorate of Cashew Research, 2011. Annual Report 2010-11, Puttur, Karnataka. 72 Pp. (Editors: P.S. Bhat and T.R. Rupa).

All India Co-ordinated Research Project on Cashew, Directorate of Cashew Research, Annual Report 2010-11. Puttur, Karnataka. 124 Pp. (Editor: T.N. Raviprasad and M.G. Bhat).

Directorate of Cashew Research, 2011. Cashew News. Newsletter Vol.16 (1). Pp. 12. (Editors: T.R. Rupa, and J.D. Adiga).

Directorate of Cashew Research, 2011. Cashew News. Newsletter Vol.16 (2). Pp. 12. (Editors: T.R. Rupa, and J.D. Adiga).

Vision 2030. Directorate of Cashew Research, Puttur, 2011. Pp. 22. (Editors: P.S. Bhat., T.R. Rupa., T.N. Raviprasad and M.G. Bhat).

### 10.5 Extension bulletins / pamphlets

Dinakara Adiga, J. 2012. Propagation and nursery management in cashew (*Geru beleyalli sasyabhivruddi mattu nursery nirvahane*). Lecture notes: State Level Cashew Seminar organized during 3-4 February, 2012 at College of Horticulture, Kolar. Pp. 31-33.

Nayak, M.G. 2012. Geru beleya pramukyate hagu avakashagalu (Importance of cashew cultivation and opportunities - in Kannada) Lecture notes: State Level Cashew Seminar organized during 3-4 February, 2012 at College of Horticulture, Kolar. Pp 1-7.

Nayak, M.G. 2012. Geru besayadalli gunamattada sasyaabhivridhiya pramukyate (Importance of quality planting material in cashew - in Kannada) - Lecture notes: State Level Cashew Seminar organized during 3-4 February, 2012 at College of Horticulture, Kolar. Pp 8-13.

Nayak, M.G. and Adiga, J.D. 2012. Training and pruning in cashew (*Geru gidagala savaruvike mattu aakaara koduvike* - in Kannada). Directorate of Cashew Research Extension Handout (Revised). Pp 6.

Nayak, M.G., Bhat, P.S., Raviprasad, T.N. and Dinakara Adiga, J. 2012. Rejuvenation of Cashew trees (*Gerumaragala Punashchetana* - in Kannada). Directorate of Cashew Research Extension Handout No.10 (Revised). Pp 6.

Raviprasad, T.N. and Bhat, P.S. 2012. Cashew Stem and Root Borer - A major pest of cashew. DCR Technical Bulletin No.13 (Hindi). Pp 12.

Yadukumar, N., Nayak, M.G., Bhat, P.S. and Dinakara Adiga, J. 2012. Improved cultivation practices in cashew, Pp 6.

*Sudhaarita Geru Besaaya* - in Kannada). Directorate of Cashew Research Extension Handout No.1 (Revised). Pp 6.

Yadukumar, N., Nayak, M.G., Bhat, P.S. and Dinakara Adiga, J. 2012. High density planting in cashew (*Geru beleyalli Ghana saandra besaaya* - in Kannada). Directorate of Cashew Research Extension Handout No.11 (Revised). Pp 6.

Raviprasad, T.N., Sajeev, M.V. and Prakash, G. Bhat. 2011. *Caju ke pedom ka kayakalp* (Hindi). (Edited and Translated).

Raviprasad, T.N., Sajeev, M.V. and Prakash, G. Bhat. 2011. *Caju khethi mein saghan ropan* (Hindi). (Edited and Translated).

Raviprasad, T.N., Sajeev, M.V. and Prakash, G. Bhat. 2011. *Caju khethi paddathiyam* (Hindi). (Edited and Translated).

### 10.6 Technical bulletins

Nayak, M.G. 2011. Pruning and canopy architecturing in cashew. DCR Technical Bulletin No.13. Pp.17 (Editors: P.S. Bhat., M.V. Sajeev, and K. Vanitha).

Nayak, M.G., Bhat, P.S. and Sajeev, M.V. 2011. Cashew production technology. DCR Technical Bulletin No. 5. Pp 43.

Raviprasad, T.N. and Bhat, P.S. 2012. Cashew Stem and Root Borer - A major pest of cashew. DCR Technical Bulletin No.13. Pp 12. (Hindi) - Reprint.

Raviprasad, T.N. and Bhat, P.S. 2012. Cashew Stem and Root Borer - A major pest of cashew. DCR Technical Bulletin No.11. Pp 12. (English) - Reprint.

## 11. LIST OF ONGOING RESEARCH PROJECTS

Project No.	Title
<b>I CROP IMPROVEMENT</b>	
1.1	Collection, conservation, evaluation and documentation of cashew germplasm (M.G. Nayak, M.G.Bhat and P.S. Bhat).
1.2	Genetic improvement of cashew for yield and quality traits (J.D. Adiga, M.G. Bhat, M.G. Nayak and Ramkesh Meena).
1.8	Application of molecular markers in cashew (Thimmappaiah).
<b>II CROP MANAGEMENT</b>	
2.2(b)	Nutrient requirement and pruning trials in high density plantations (R. Rejani).
2.11	Performance of high yielding varieties of cashew in different high density planting (R. Rejani and J.D. Adiga).
2.14	Geographical information system (GIS) and remote sensing (RS) technologies to develop a spatial database and to identify suitable areas for expanding cashew cultivation - A study at farm level (R. Rejani, M.G. Nayak and T.R. Rupa).
2.15	Root stock studies in cashew (J.D. Adiga and M.G. Nayak).
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, R. Rejani and D. Kalaivanan).
2.18	Effect of Paclobutrazol on growth and yield of cashew (J.D. Adiga and M.G. Nayak).
2.19	Irrigation requirement for cashew under high density planting system (R. Rejani, J.D. Adiga and T.R. Rupa).
2.20	Organic farming in cashew (D. Kalaivanan, T.R. Rupa and P.S. Bhat).
<b>III CROP PROTECTION</b>	
3.15	Evaluation of alternate techniques for the management of cashew stem and root borer (T.N. Raviprasad and P.S. Bhat).
3.16	Studies on causes of black spot formation on cashew kernels (T.N.Raviprasad).
3.17	Biodiversity of arthropod fauna in cashew eco-system (P.S. Bhat, T.N. Raviprasad and K.Vanitha).
3.18	Evaluation of certain repellents against storage insect pest ( <i>Ephestia cautella</i> - Pyralidae : Lepidoptera) infesting stored cashew kernels (T.N. Raviprasad and P.S. Bhat).

Network	ORP on management of sucking pests in horticultural crops (ICAR funded through IIHR, Bengaluru) (P.S. Bhat and T.N. Raviprasad).
<b>IV</b>	<b>POST - HARVEST TECHNOLOGY</b>
4.12	Studies on alternate energy utilization of cashewnut shell cake (D. Balasubramanian and Sandeep Gadgil).
4.14	Development of compact type drum roasting machine for raw cashewnuts (D. Balasubramanian and S.D. Deshpande).
NAIP	A value chain on cashew for domestic and export market (Consortium partner: D. Balasubramanian).
<b>V</b>	<b>TRANSFER OF TECHNOLOGY AND COMPUTER APPLICATION</b>
5.1	Transfer of technology programme in cashew (M.G. Nayak, P.S. Bhat, J.D. Adiga and T.R. Rupa).
5.2	Impact of cashew production technology on area, production and productivity of cashew (Sajeev, M.V.).

## 12. IMPORTANT MEETINGS AND SIGNIFICANT DECISIONS

### 12.1 Research Advisory Committee (RAC) (w.e.f. 8 December, 2011)

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

<p>Dr. K.V. Ramana Former ADG (Hort.) Door No. 86-2-21/2 Sangeetam Venkatareddy Street Jawaharlal Nehru Road (JN Road) Rajahmundry - 533 103 East Godavari District Andhra Pradesh.</p>	Member
<p>Prof. M. Udayakumar Emeritus Scientist Department of Crop Physiology University of Agricultural Sciences GKVK, Bengaluru - 560 065 Karnataka.</p>	Member
<p>Dr. M. Gopalakrishna Bhat Director Directorate of Cashew Research Puttur - 574 202, D.K. District Karnataka.</p>	Member
<p>Dr. P.L. Saroj Assistant Director General (Hort.I) Indian Council of Agricultural Research Krishi Anusandhan Bhavan-II Pusa Gate New Delhi - 110 012.</p>	Member
<p>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.</p>	Member
<p>Sri. N. Narayana Bhat Rtd. Bank Manager Noojibail House Manchi Post, Buntwal Tq. Dakshina Kannada District Karnataka - 574 323.</p>	Member
<p>Dr. T.N. Raviprasad Senior Scientist (Agricultural Entomology) Directorate of Cashew Research Puttur - 574 202, Karnataka.</p>	Member Secretary

(F.No.7-1/2010 I.A-V dated 14 October, 2011, from Director (Hort.) ICAR, KAB-II, New Delhi)

The third meeting of the fifth RAC (15<sup>th</sup> meeting) of the Directorate was held during 9-10 May, 2011 under the Chairmanship of Dr. D.P. Ray, Vice Chancellor, OUAT, Bhubaneswar. Dr. M.G. Bhat, Director, DCR briefed the members of RAC about the present scenario of cashew production and the research activities that are going on in cashew at the Directorate. Later, the chairman and members of fifth RAC made their opening remarks about the research activities that are being carried out at the Directorate. Chairman, Dr. D.P. Ray opined that research work should cater to the needs of the farmer. He said that major contribution to GDP

comes from Horticulture, Animal Sciences and Fisheries. He cautioned that recommendations given by the researcher should be useful to the farming community. Dr. P.M. Salimath, Director of Research, UAS, Dharwad; Dr. P.M. Haldankar, Professor and Head, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli; Dr. M.N. Khare, Ex-Dean, JNKVV, Jabalpur and Sri. N. Narayana Bhat (Non-Official Member), Karnataka participated in the meeting and the progress made under the research projects was discussed and recommendations were made.

## 12.2 Institute Management Committee (IMC)

Name and Address	Status
Dr. M.G. Bhat, Director, DCR, Puttur - 574 202, Dakshina Kannada, Karnataka.	Chairman
Dr. S. Rajan, 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, Karnataka.	Member
Dr. Anitha Karun, Principal Scientist, Division of Crop Improvement, Central Plantation Crops Research Institute, Kudlu, 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, Buntwal Taluk, Dakshina Kannada, Karnataka.	Member
Senior Finance and Accounts Officer, Central Plantation Crops Research Institute, Kasaragod - 671 124, Kerala.	Member
Asst. Administrative Officer, DCR, Puttur - 574 202, Dakshina Kannada, Karnataka.	Member

The Institute Management Committee met twice on 31 January, 2012 and 26 March, 2012 and reviewed the progress of research projects and ad-hoc projects. The equipments to be purchased and the works to be undertaken during the current year of XI Plan period were finalized during the meetings. The IMC's tenure is three years from 11 February, 2010.

### 12.3 Institute Research Committee (IRC)

The 24<sup>th</sup> meeting of Institute Research Committee was held during 28-29 June, 2011. Dr. M.G. Bhat, Director, DCR and Chairman of the IRC meeting briefed about the progress made in

different research projects. There were 10 technical sessions on "Crop Improvement", "Crop Management" [chaired by Dr. N.G. Raghu Mohan, Former Principal Scientist (Soil Science) & Former Head, Regional Centre of NBSS&LUP, Bengaluru], "Crop Protection" [chaired by Dr. M. Nagesh, Principal Scientist (Agricultural Entomology), NBAII, Bengaluru], "Post Harvest Technology" and "Transfer of Technology and Computer Application". The scientists of the Directorate presented progress made under various projects and technical programme of all the projects was finalized.

### 12.4 Institute Joint Staff Council (IJSC)

VIII IJSC (w.e.f. 1 March, 2011)

<b>Official side</b>	
Dr. M.G. Bhat	Chairman
Dr. M.G. Nayak	Member
Dr. T.N. Raviprasad	Member
Shri. T.S. Ponnaiah	Member (w.e.f. 22 December, 2011)
Shri. K.M. Jayarama Naik	Member (Upto 8 June, 2011)
Shri. K.M. Lingaraja	Member (w.e.f. 26 March, 2011)
Dr. D. Kalaivanan	Member Secretary
<b>Staff side</b>	
Smt. K. Padmini Kutty	Member Secretary
Smt. 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.

## 12.5 राजभाषा कार्यान्वयन एवं प्रगती

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

वर्ष 2011-12 में राजभाषा कार्यान्वयन समिति की चार बैठकें आयोजित हुईं। हर बैठक में निदेशालय में हो रही हिन्दी कार्यान्वयन के संबंध में चर्चा किया गया। जरूरी विचारों पर केन्द्र से आए पत्रों एवं सूचना के बारे में भी चर्चा किया गया। जैसा कि हमें वार्षिक कार्यक्रम के अनुसार निश्चित लक्ष्य दिया गया था उन लक्ष्यों के प्राप्ति के लिए की जा रही कार्रवायियों के बारे में भी चर्चा किया गया। अनेक निर्णयों भी लिए गए।

हिन्दी में कार्यालयीन कार्य कर रहे कर्मचारियों को प्रोत्साह देने के लिए पुरस्कार योजना जारी है। इससे प्रशासन अनुभाग में हिन्दी में काम करनेवालों में उत्साह बड़ा है। इस निदेशालय के बहुसंख्यक कर्मचारी हिन्दी में कार्यसाधक ज्ञान प्राप्त कर चुके हैं। बाकी कर्मचारियों को प्रशिक्षण देने के लिए कोशिश जारी है।

कार्यालय में सभी नामफलक, प्रपत्र, मोहरे आदियों को द्विभाषी में बनवाया गया है। कर्मचारियों में हिन्दी में काम करने की जिज्ञास दूर करने के लिए समय समय पर हिन्दी कार्यशालाओं का आयोजन किया जा रहा है। सितंबर में आयोजित हुई हिन्दी पखवाडा में हमेशा की तरह कर्मचारी बड़े उत्साह से भाग लिये हैं।

### पुत्तूर नगर राजभाषा कार्यान्वयन समिति (नराकास)

काजू अनुसंधान निदेशालय, पुत्तूर नगर राजभाषा कार्यान्वयन समिति (नराकास) के संयोजक कार्यालय है। यह निदेशालय पुत्तूर नराकास के 23 सदस्य कार्यालयों की राजभाषा गतिविधियों की समीक्षा करती है और उनको बढ़ावा देने के लिए जरूरी कार्यक्रमों को संयोजन करती है।

इस वर्ष, जुलाई और जनेवरी में, पुत्तूर नगरकास की दो अर्धवार्षिक बैठकें आयोजित हुईं। इन बैठकों में पुत्तूर और विट्टल के सभी केन्द्र सरकारी कार्यालयों से कार्यालय प्रधान / अधिकारी भाग लिए। हर कार्यालय में हो रही गतिविधियों की समीक्षा करना और उन्हें आगे बढ़ाने के लिए जरूरी सूचना, मार्गदर्शन देना इन बैठकों का उद्देश्य था। इसी दृष्टि से अनेक विचारों पर चर्चा भी किए गए और निर्णय भी लिए गए।

सभी सदस्य संघटनों की कर्मचारियों की सुविधा के लिए जुलाई महिने में एक दिन की हिन्दी कार्यशाला आयोजन किया गया था। अनेक विद्वानों ने कार्यशाला में कर्मचारियों को मार्गदर्शन किया।

सितंबर 14-28 तक बहुत उत्साहपूर्ण वातावरण में हिन्दी पखवाडा मनाया गया। इस अवसर पर कर्मचारियों और विद्यार्थियों के लिए अनेक प्रतियोगिताओं का आयोजन किया गया। विद्यार्थियों को, हिन्दी सीखने की प्रति प्रेरणा देने के लिए, हिन्दी परीक्षाओं में उत्तम अंक पाने के लिए नगद पुरस्कार से सम्मानित किया गया। हिन्दी की प्रसारण को विस्तृत रूप देने की दृष्टि से हिन्दी अध्यापकों को, पोषकों को भी कार्यक्रम में शामिल किया गया। इस कार्यालय में, सदस्य कार्यालय के सभी कर्मचारियों को हिन्दी सीखने के लिए जरूरी सुविधा दिया जा रहा है।

### 13. PARTICIPATION IN SYMPOSIA / CONFERENCES / SEMINARS / MEETINGS

Bhat, M.G.	Participated in the Divisional Meeting of Directors of the Institutes under Horticulture Division convened by DDG (Hort.), ICAR at NASC Complex, New Delhi.	11 April, 2011.
Nayak, M.G.	Workshop on Biofuel organized by Nagarika Seva Trust, Guruvayanakere, Puttur, Karnataka.	21 May, 2011.
Nayak, M.G.	Review meeting of Cashew Development Programmes in the country organized by DCCD, Kochi, Kerala.	24 May, 2011.
Bhat, M.G.	Participated in the National Conference on Horti-business-linking farmers with market and 3 <sup>rd</sup> Swadesh Prem Jagriti Sangosthi-2011 organized by ASM Foundation in collaboration with Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut at Dehradun.	28-31 May, 2011.
Bhat, M.G.	Participated in the Interaction Meeting of Project Directors / Project Coordinators held under the Chairmanship of DG, ICAR at CIAE, Bhopal.	16 June, 2011.
Director and All Scientists of the Directorate	Attended Innovative Cashew Farmers Meet - 2011 at DCR, Puttur.	18 June, 2011.
Bhat, M.G.	Participated in the meeting of Working Sub-Group of Horticulture Crops held under the Chairmanship of DDG (Hort.), ICAR at Committee Room, NAAS Block, NASC Complex, New Delhi.	24 June, 2011.
Raviprasad, T.N.	Participated in the second meeting of the Sub Group 2: Assessing Growth Rate of Horticulture sector in XII Five Year Plan as a part of working group on Horticulture and Plantation Crops at Indian Institute of Horticultural Research, Hessaraghatta, Bengaluru.	30 June, 2011.
Bhat, M.G.	Participated in the ICAR Directors' Conference and ICAR Foundation Day at NASC Complex, New Delhi.	15-16 July, 2011.
Bhat, M.G.	Attended 6 <sup>th</sup> Scientific Advisory Committee meeting of KVK, Mangalore	19 July, 2011.
Nayak, M.G. Bhat, P.S. Raviprasad, T.N.	Participated as experts in the Sub Group Meeting on Technical Aspects of Cashew – G.A.P. & INM / IPM held at ICAR Res. Complex for Goa, Ela, Old Goa.	23 July, 2011.
Bhat, M.G.	Participated in the Review Meeting of AICRP's chaired by DG, ICAR on 25 July, 2011. Participated in the 2 <sup>nd</sup> Working Sub-Group Meeting on Horticultural Crops at NASC, Pusa, New Delhi on 26 July, 2011. Participated in the NBPGR - NAGS National Workshop held at NBPGR, Pusa, New Delhi during 29-30 July, 2011.	25-30 July, 2011.

Nayak, M.G.	Participated in the NBPGR - NAGS National Workshop held at NBPGR, Pusa, New Delhi.	29-30 July, 2011.
Bhat, P.S. Raviprasad, T.N. Vanitha, K.	Attended the National Meeting on Agricultural Entomology for 21 <sup>st</sup> century: The way forward held at National Bureau of Agriculturally Important Insects, Bengaluru.	25-26 August 2011.
Nayak, M.G.	Acted as resource person on cashew in farmers seminar conducted by Karnataka State Department of Horticulture at Kumbra in Puttur taluk, Karnataka.	9 September, 2011.
Rupa, T.R.	Attended National Stakeholders Consultation on Climate Change at Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad.	19-20 September, 2011.
Bhat, M.G.	Participated in the 154 <sup>th</sup> Board Meeting & Annual General Body Meeting of KCDC Ltd. in the Registered Office of KCDC Ltd. at Mangalore.	24 September, 2011.
Bhat, M.G.	Participated in the 2 <sup>nd</sup> Special Meeting of Vice-Chancellors/ Comptrollers of SAUs and Project Coordinators and discussed about the AICRP Projects and related financial issues held at NASC Complex, New Delhi under the chairmanship of Secretary, DARE & DG, ICAR.	26-27 September, 2011.
Rupa, T.R.	Attended International Conference on Issues for Climate Change, Land Use Diversification and Biotechnological Tools for Livelihood Security, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut (U.P.).	8-10 October, 2011.
Bhat, M.G.	Attended XX Biennial Group Meeting of AICRP Palms at CPCRI, Kasaragod, Karnataka	15-16 October, 2011.
Bhat, M.G. Nayak, M.G. Bhat, P.S.	Participated in Krishi Mela in Zonal Agricultural Research Station, Brahmavar, Karnataka	18 October, 2011.
Rupa, T.R.	Attended Brainstorming Meet on Water at National Bureau of Fish Genetic Resources (NBFGR), Lucknow.	18-19 October, 2011.
Bhat, M.G.	Participated in the 155 <sup>th</sup> Board Meeting of KCDC Ltd. in the Registered Office of KCDC Ltd. at Mangalore.	4 November, 2011.
Bhat, M.G.	Participated in the Interaction Meeting at NBPGR, New Delhi and finalized draft proposals for National Network Project on PGR Management and Use for XII Plan under Agrobiodiversity Platform of ICAR.	18-19 November, 2011.
Kalaivanan, D.	Participated in the International Workshop on Alternative Analytical Technology for Soil Nutrient Analysis held at MCRC & IIT-Madras.	25-27 November, 2011.

Nayak, M.G. Balsubramanian, D. Kalaivanan, D.	Participated in the first International Symposium on Cashewnut conducted jointly by International Society of Horticulture Science (ISHS) and Tamil Nadu Agricultural University (TNAU) conducted at AC&RI, TNAU, Madurai, Tamil Nadu.	9-12 December, 2011.
Nayak, M.G.	Participated and delivered a talk on Need of the day in cashew cultivation in National Cashew Stake Holders meet at DCR, Puttur.	23 December, 2011.
Director and All Scientists of the Directorate	Participated in the National Expert Consultation on Cashew with the theme of Challenges and strategies for higher productivity and quality of cashew as a part of Silver Jubilee Celebrations (1986-2011) of Directorate Cashew Research held at Directorate of Cashew Research, Puttur.	23-24 December, 2011.
Director and All Scientists of the Directorate	Attended National Group Meeting of scientists of AICRP on Cashew - 2011 at DCR, Puttur.	25-27 December, 2011.
Bhat, M.G.	Participated and presented Presidential Address on Organic Farming: Prospects and Problems in the State Level Workshop on Challenges of Crops Health Management in Organic Farming held in College of Agriculture (KAU), Padannakkad, Kasaragod Dist. Kerala.	5 January, 2012
Nayak, M.G.	Participated in Krishi Mela organized by SKDRDP, Dharmasthala at Narimogaru village in Puttur taluk, Karnataka.	15 January, 2012.
Raviprasad, T.N.	Participated as resource person in Brainstorming Session on Pest Management of mango, cashew, coconut and sapota held at Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra.	17-18 January, 2012.
Bhat, M.G.	Participated in the First Joint Committee Meeting of the Standing Committee and Working Committee of XX Plantation Crops Symposium (PLACROSYM XX) as a Member of the Standing Committee for PLACROSYM, organized by UPASI Tea Research Foundation, Tea Research Institute, Valparai, Coimbatore at Hotel Jenneys Residency, Avinashi Road, Coimbatore.	20 January, 2012.
Bhat, M.G. Rupa, T.R.	Participated in the National Dialogue on Climate Resilient Horticulture held at IIHR, Bengaluru and also presented a paper entitled Climate change effects on cashew and adaptation strategies.	28-29 January, 2012.
Nayak, M.G. Raviprasad, T.N. Adiga, J.D.	Participated as subject matter specialist in State level seminar on Cashew held at College of Horticulture, Kolar.	4 February, 2012

Nayak, M.G.	Participated and acted as resource person in Cashew Day organized by HRS (UHS), Ullal.	10 February, 2012.
Nayak, M.G.	Participated and delivered lecture on cashew varieties, package of practices, canopy management in Cashew Seminar cum training programme organized by KVK and NGO Academy for Sustainable Development, Shimoga, Karnataka.	16 February, 2012.
Bhat, M.G.	Participated in the Directors – Vice Chancellors Interface and ICAR Directors’ Conference held at AP Shinde Symposium Hall, NASC Complex, DPSM, New Delhi.	17-18 February, 2012.
Nayak, M.G.	Participated in the 2 <sup>nd</sup> Hort. Industry Meet organized by IIHR, Bengaluru.	6-7 March, 2012.
Bhat, M.G.	Participated in the 156 <sup>th</sup> Board Meeting of KCDC Ltd. in the Registered Office of KCDC Ltd., Mangalore.	19 March, 2012.

## 14. FARMER’S DAY / KRISHI MELA / CAMPAIGNS / CONSULTANCY / SPECIAL ASSIGNMENT

Bhat, M.G. Nayak, M.G. Bhat, P.S.	Krishi Mela organized at Zonal Agricultural Research Station, Brahmavar, Udipi district, Karnataka.	17 October, 2011.
Raviprasad, T.N.	Organized thematic campaigns on CSRB management in Goa at different locations viz., Moula-Batim, Tiswadi at Wadaval, Latam-Barcem, Bicholim. Barcem, Quepem, Shelap-Khurd, Valpoi, Sattari.	10-13 January, 2012.
Nayak, M.G. Bhat, P.S.	Geru mela organized at Horticultural Research Station (HRS), Ullal, Dakshina Kannada district, Karnataka.	10 February, 2012.
Raviprasad, T.N.	Organized thematic campaigns on CSRB management in the state of Maharashtra at Vengurle, Vaibhavwadi and Dodamarg.	17-18 February, 2012.

## 15. DELEGATION / TRAINING

Balasubramanian, D.	Training programme on ITM - IPR organized by CIFT, Cochin.	25-26 April, 2011.
Adiga, J.D. Kalaivanan, D.	Training programme on Data Analysis Using SAS of NAIP project on SSC for NARS held at UAS, Bengaluru.	8-13 August, 2011.
Adiga, J.D.	Attended Refresher course on Agricultural Research Management for Newly Recruited Senior / Principal Scientists held at NAARM, Hyderabad.	3-23 November, 2011.
Kalaivanan, D.	FAO HORTIVAR training held at AC & RI, Madurai, Tamil Nadu.	9-12 December, 2011.
Kalaivanan, D.	Participated in the Workshop Cum Installation of SAS training programme held at UAS, Bengaluru.	13-14 December, 2011.
Rupa, T.R. Rejani, R.	Training programme on Effectiveness and Enhancement Programme for Scientists (Programme I) held at the Institute of Management Training and Research (IMTR), Goa.	16-20 January 2012.

## 16. RADIO TALK / INTERVIEW / TV PROGRAMMES

### i) RADIO TALK / INTERVIEW

Bhat, P.S.	Management of tea mosquito bug in cashew and it's management - at All India Radio (AIR), Mangalore.	27 April, 2011.
Raviprasad, T.N.	Management of cashew stem and root borers in cashew and it's management - at AIR, Mangalore.	4 May, 2011.
Adiga, J.D.	Planting and aftercare in cashew - at AIR, Mangalore.	11 October, 2011.
Nayak, M.G.	Pruning and canopy management in cashew - at AIR, Mangalore.	9 November, 2011.
Nayak, M.G.	Recorded a radio talk on cashew varieties and ultra high density planting - at AIR, Mangalore.	8 March, 2012.

### ii) TV PROGRAMMES

Nayak, M.G.	A TV serial on various aspects of cashew cultivation: Softwood grafting and nursery management – by Chandana Kannada channel of Doordarshan, Bengaluru.	April, 2011 onwards
Sajeev, M.V.	A series of recordings on various aspects of cashew production technology - by Chandana Kannada channel of Doordarshan, Bengaluru.	April, 2011 onwards.
Adiga, J.D.	Recorded two TV talks entitled Planting and aftercare in cashew (Part-1) and Planting and aftercare in cashew (Part-2) - regional channel of Doordarshan, Bengaluru.	20 June, 2011 and 27 June, 2011, respectively.
Bhat, M.G.	Recorded a TV talk on Cashew scenario and improved cashew varieties - by Chandana Kannada channel of Doordarshan, Bengaluru.	20 January, 2012.

## 17. DISTINGUISHED VISITORS

Dr. Vijay Metha Vice Chancellor Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth Dapoli, Maharashtra.	18 June, 2011.
Dr. H.P. Singh Deputy Director General (Horticulture), ICAR KAB-II, Pusa Campus, New Delhi - 110 012.	23 December, 2011.
Dr. S. Ayyappan Secretary, Department of Agricultural Research and Education (DARE) and Director General, Indian Council of Agricultural Research (ICAR) Krishi Bhavan, Dr. Rajendra Prasad Road New Delhi - 110 114.	24 December, 2011.
Dr. S. Rajan Assistant Director General (Hort.-I) ICAR, KAB-II, Pusa Campus, New Delhi - 110 012.	27 December, 2011.
Dr. M. Anandaraj Director Indian Institute of Spices Research, Calicut, Kerala.	31 December, 2011.
Dr. K.V. Peter Former Vice Chancellor, KAU Director, World Noni Research Foundation 12 Rajiv Gandhi Road, Sreenivasanagar P.O. Perungudi, Chennai - 96.	6 February, 2012.
Dr. Umesh Srivastava ADG (Hort.-II) ICAR, KAB-II, Pusa Campus, New Delhi - 110 012.	14 March, 2012.

## 18. PERSONNEL

### 18.1 Managerial

Dr. M.G. Bhat                      Director

### 18.2 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                      Senior Scientist (Agricultural Entomology)
6. Dr. D. Balasubramanian                      Senior Scientist (Agricultural Engg. - AS and PE)
7. Dr. J.D. Adiga                      Senior Scientist (Horticulture)

- |     |                       |   |
|-----|-----------------------|---|
| 8.  | Dr. (Mrs.) R. Rejani  | Scientist (Soil and Water Cons. Engg.)                      |
| 9.  | Dr. P.D. Sreekanth    | Scientist (Computer Application) (upto 10 May, 2011)        |
| 10. | Dr. Sajeev, M.V.      | Scientist (Agricultural Extension) (w.e.f. 7 April, 2011)   |
| 11. | Mr. Ramkesh Meena     | Scientist (Horticulture)                                    |
| 12. | Dr. (Mrs.) K. Vanitha | Scientist (Agricultural Entomology) (w.e.f. 8 August, 2011) |
| 13. | Dr. D. Kalaivanan     | Scientist (Soil Science)                                    |

### 18.3 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) (w.e.f. 24 August, 2010)    |
| 7.  | Sri. R. Lakshmisha        | Technical Officer (T-6) (w.e.f. 15 September, 2010) |
| 8.  | Sri. K.V. Ramesh Babu     | Technical Officer (T-6) (w.e.f. 21 September, 2010) |
| 9.  | Sri. N. Manikandan        | Technical Officer (T-5)                             |
| 10. | Sri. R. Muthuraju         | Technical Officer (Computer) (T-5)                  |
| 11. | Sri. K. Seetharama        | Technical Officer (T-5) (Farm)                      |
| 12. | Sri. A. Poovappa Gowda    | Technical Officer (T-5) (w.e.f. 3 February, 2010)   |
| 13. | Sri. K. Babu Poojary      | Technical Assistant (T-3) (w.e.f. 20 July, 2010)    |
| 14. | Sri. Ravishankar Prasad   | Technical Assistant (T-3) (w.e.f. 28 July, 2010)    |
| 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. Honappa Naik      | Technical Assistant (T-1)                           |

### 18.4 Administration

- |     |                         |   |
|-----|-------------------------|---|
| 1.  | Sri. T.S. Ponnaiah      | Administrative Officer (w.e.f. 1 July, 2011)                      |
| 2.  | Sri. K.M. Jayarama Naik | Assistant Administrative Officer (Stores) (upto 8 June, 2011)     |
| 3.  | Sri. K.M. Lingaraja     | Assistant Administrative Officer                                  |
| 4.  | Ms. M. Ratna Ranjani    | Assistant Administrative Officer (Stores) w.e.f. (6 August, 2011) |
| 5.  | Sri. O.G. Varghese      | Private Secretary   |
| 6.  | Ms. B. Jayashree        | Personal Assistant  |
| 7.  | Ms. K. Reshma           | Personal Assistant (w.e.f. 30 March, 2012)                        |
| 8.  | Ms. Winne Lobo          | Assistant   |
| 9.  | Ms. M. Leela            | Assistant   |
| 10. | Sri. Uma Shankar        | UDC   |
| 11. | Ms. Padmini Kutty       | LDC   |
| 12. | Sri. K. Balappa Gowda   | Gestetner Operator  |

## 19. MISCELLANEOUS

### 19.1 Silver Jubilee Celebrations (1986-2011) of the Directorate of Cashew Research, Puttur

The Silver Jubilee Celebrations (1986-2011) of Directorate of Cashew Research (DCR) was held during 23-24 December, 2011 at its headquarters DCR, Puttur to commemorate the completion of 25 years of useful existence and having served the farmers and development departments by developing several improved cashew production technologies. As a part of Silver Jubilee Celebrations, a 'National Expert Consultation on Cashew' with the theme 'Challenges and Strategies for Higher Productivity and Quality of Cashew' and a 'National Cashew Stakeholders Meet' were organized. Around 300 delegates including scientists, technical experts, processors and cashew farmers participated in the Celebrations. Dr. M.G. Bhat, Director was the Chairman and Dr. M.G. Nayak, Principal Scientist (Horticulture) was the Organizing Secretary of the Organizing Committee of the Silver Jubilee Celebrations.

In the forenoon of 23 December, 2011, the Silver Jubilee Celebrations of the DCR was inaugurated by the Chief Guest Smt. Mallika Prasad, the Hon'ble Member of Legislative Assembly (MLA), Puttur constituency. Dr. M.G. Bhat, Director, DCR extended a warm welcome to the Chief Guest,



**Inauguration of the celebrations**

Guests of Honour, distinguished dignitaries and invitees and gave a brief introduction on the establishment of Cashew Research in India, establishment of NRCC / DCR and AICRP-Cashew. Dr. Bhat briefly dwelt on progress of cashew cultivation in India through the adoption of technological innovations made at this Directorate.



**Welcome by Dr. M.G. Bhat, Director, DCR**

The Chief Guest Smt. Mallika Prasad, in her Inaugural Address emphasized on the role of scientists in increasing the food production. She exhorted the scientists to think and plan their strategies to give best to the society.

The function was presided over by Dr. K.V. Ahmed Bavappa, Former Director, CPCRI with additional charge of Director, DCR. Dr. M.K. Nair, Former Director, CPCRI with additional charge of Director, DCR and Mr. Venkatesh N. Hubballi, Director, DCCD, Kochi were the Guests of Honour on the occasion. Silver Jubilee Souvenir, two Technical Bulletins and a book on Cashew were released during the occasion. Dr. H.P. Singh, DDG (Hort.); Dr. K.V. Ahmed Bavappa; Dr. M.K. Nair and Dr. M.G. Bhat were felicitated for their significant contributions made to the cashew research system. The guests spoke aptly on the occasion. Inaugural function formally came to a close with a vote of thanks by Dr. M.G. Nayak, Organising Secretary, Silver Jubilee Celebrations. Later Smt. Mallika Prasad, MLA inaugurated the exhibition in which various southern ICAR institutes, Development Departments, Agricultural Entrepreneurs, Self-Help Groups etc. participated.

In the afternoon of 23 December, 2011, a 'National Cashew Stakeholders Meet' was organized in which various aspects pertaining to present status of cashew production and post production were critically discussed among the cashew stakeholders viz., farmers, cashew processors and exporters, nursery men, economists, scientists and officials of developmental departments. Dr. M.G. Nayak, Principal Scientist (Horticulture), DCR; Shri. K.B.

Dundi, Joint Director of Horticulture, Department of Horticulture, Bengaluru; Shri. N. Achuta Moodithaya, a progressive farmer and Dr. Vigneshwara Varmudi, Associate Professor (Economics) delivered the lectures in the meet which generated lot of discussion. During the meet, five cashew farmers were honoured for their innovative role in increasing productivity of cashew after adopting improved cashew production technologies.

In the afternoon of 23 December, 2011 and 24 December, 2011, a 'National Expert Consultation on Cashew' was held, which comprised of six technical sessions viz., Crop improvement and biotechnological approaches, Developmental strategies, Natural resource management for higher productivity, Horticultural interventions for enhancing productivity, Insect pest management and, Processing and value addition. There was also Special Technical Session chaired by Dr. H.P. Singh, DDG (Hort.) in which a presentation on Biotechnological / Molecular approaches for improvement of horticultural crops was made by Dr. V.A. Parthasarathy, Emeritus Scientist and Former Director, Indian Institute of Spices Research, Calicut. In the technical sessions, there was in depth discussion on various strategies and challenges for higher productivity and quality of cashew.

The Valedictory Function was held in the afternoon of 24 December, 2011 with Dr. H.P. Singh, DDG (Hort.) in the chair. Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR was the Chief Guest. Dr. M.G. Bhat, Director, DCR, Puttur and Chairman of Silver Jubilee Celebrations of DCR highlighted the proceedings of the Inaugural Session of Silver Jubilee Celebrations followed by National Cashew Stakeholders Meet and National Expert Consultation on Cashew.

The recommendations emerged out in the Technical Sessions of National Expert Consultation on Cashew were presented by respective chairman / rapporteur of the sessions. The recommendations were approved by the house for implementation after certain modifications. Dr. H.P. Singh, Deputy Director General (Hort.), in his remarks, appealed the scientists and other participants to follow the strategies emerged out during National Expert Consultation on Cashew to withstand the global

competition in cashew production and trade from other cashew growing countries. He exhorted the cashew scientists to think and plan their strategies for achieving quantum jump in cashew production.



**Address by Dr. H.P. Singh, DDG (Hort.), ICAR**

Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR in Plenary Lecture, commended the achievements made by Directorate of Cashew Research, Puttur in terms of possessing largest germplasm collection of cashew in the country as well as developing large number of technologies in association with centres of AICRP on cashew. He also expressed his satisfaction for organizing National Expert Consultation on Cashew to commemorate the completion of 25 years of useful existence of Directorate of Cashew Research at Puttur. He hoped that action plan drawn during the National Expert Consultation on Cashew would help



**Address by Dr. S. Ayyappan, DG, ICAR**

in enhancing productivity and quality of cashew in meeting the demands of domestic as well as international market. At the end, Dr. M.G. Nayak, Organizing Secretary, Silver Jubilee Celebrations proposed a vote of thanks.

## 19.2 Visitors

Visitors (around 3000) viz., farmers, development department officials and students were

taken to various experimental plots, cashew museum and laboratories and were explained about cashew cultivation practices and research findings of this Directorate.

### 19.3 Consultancies

Scientist of this Directorate served as a member of the team for evaluation and inspection of cashew nurseries and cashew frontline technology programmes in various parts of the country. The team visited various newly planted orchards of Goa Forest Development Corporation, Goa for inspection and evaluation during 21-22 July, 2011.

A team of scientists of this Directorate provided advisory visit to 'ORDER'- an NGO working on tribal welfare at Tumkur, Karnataka on 28 November, 2011.

Two scientists of this Directorate visited the cashew orchards established by tribal farmers with guidance from BAIF, Pune (DRUVA in Gujarat) during 22-26 January, 2012. They studied the situation and conditions of cashew orchards in the wadis located in Navsari, Dang and Valsad districts of South Gujarat and offered consultancy for the improvement of cashew orchards and the production.

### 19.5 Average weather data (2011-12)

Month	Temperature (°C)		Humidity (%)		Rainy Days	Rainfall (mm)	Mean wind velocity (km/h)	Sunshine hours (h)	Evaporation (mm)
	Max.	Min.	FN	AN					
Apr.11	37.8	23.0	92	45	6	92.4	NA	6.7	5.1
May 11	36.6	23.2	93	54	5	211.8	NA	7.2	5.0
Jun.11	31.3	22.8	98	89	26	1085.6	NA	2.2	3.0
Jul.11	30.6	22.6	98	92	29	1187.8	NA	0.8	3.1
Aug.11	31.2	22.9	97	85	30	662.4	NA	0.8	3.7
Sept.11	31.9	22.3	96	80	18	367.6	NA	3.6	3.9
Oct.11	35.2	22.6	95	60	19	364.3	NA	5.4	4.6
Nov.11	33.2	19.5	93	53	4	25.9	0.3	7.2	4.8
Dec.11	33.7	17.4	92	46	0	0	0.2	8.6	5.0
Jan.12	33.7	17.4	93	41	0	0	0.6	8.7	5.1
Feb.12	36.1	19.3	92	40	0	0	1.0	8.8	5.3
Mar.12	36.2	21.3	90	41	0	0	1.9	6.9	5.3
						3997.8			

NA = Not Available

### 19.4 Obituary



Dr. K.V. Nagaraja, Former Principal Scientist (Biochemistry) of this Directorate breathed his last on 4 November, 2011 in Chennapattana, Karnataka due to heart attack. He was born on 20 October, 1948. He had a very brilliant academic career. Dr. K.V. Nagaraja worked at Directorate of Cashew Research, Puttur as Senior Scientist and Principal Scientist for about 23 years. He also worked at CPCRI, Regional Station, Vittal, Karnataka for about four years. He retired from ICAR service as Principal Scientist, DCR on superannuation on 31 October, 2010. He made commendable contributions in biochemical aspects of cashew and his contributions will be the source of inspiration to the young scientists and colleagues for all time to come. Dr. K.V. Nagaraja was a dedicated and most accomplished scientist. He published more than 60 research papers in various journals of national and international repute. He was fellow of the Indian Society for Plantation Crops. By passing away of Dr. K.V. Nagaraja, Scientific community of cashew lost a renowned scientist. The staff of this Directorate deeply mourn the demise of Dr. K.V. Nagaraja and pray to Almighty for peace to the departed soul.

### 19.6 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 bibliography on cashew (1985-1994)	75.00
4	Catalogue of minimum descriptors of cashew	
	Germplasm accessions - I	165.00
	Germplasm accessions - II	125.00
	Germplasm accessions - III	128.00
5	Status of cashew germplasm collection in India (Booklet)	
6	Compendium of concluded research projects (1986 -2001)	
7	Sudharitha geru besaya kramagalu (Booklet in Kannada)	15.00
8	Cashew nutritive value (Revised) (Brochure)	
9	Database on cashewnut processing in India (2003)	100.00
10	Directory of cashewnut processing industries in India (2003)	100.00
11	Process catalogue on development of economically viable on-farm cashewnut processing	45.00
12	Cashew cultivation practices (Pamphlet)	
13	Annotated bibliography on cashew 1995-2007	205.00
14	Soil and water management in cashew plantations	30.00
15	Biochemical characterization of released varieties of cashew	85.00
16	Pruning and canopy architecturing in cashew	40.00

Price indicated above does not include postage.

Address your enquiries to the Director, DCR, Puttur - 574 202, Dakshina Kannada, Karnataka.

Besides, soil and leaf analysis are undertaken on payment basis.