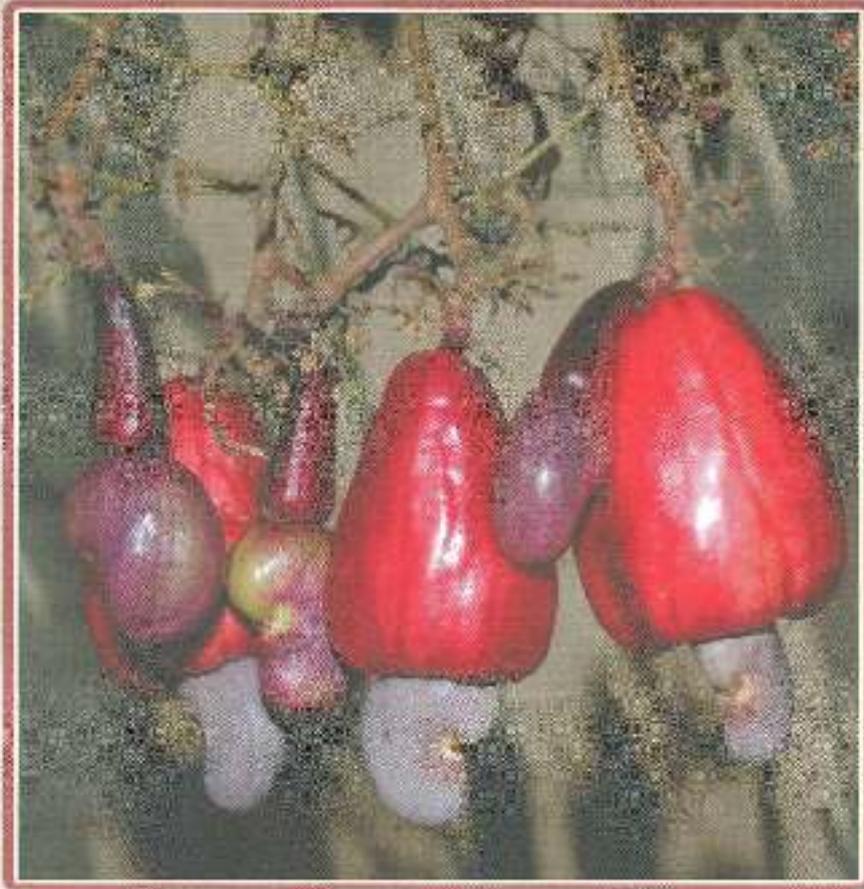


वार्षिक प्रतिवेदन
ANNUAL REPORT
2010 - 11



काजू अनुसंधान निदेशालय

(भारतीय कृषि अनुसंधान परिषद्)
पुत्तूर - 574 202, दक्षिण कन्नड, कर्नाटक

DIRECTORATE OF CASHEW RESEARCH

(Indian Council of Agricultural Research)
PUTTUR - 574 202, DAKSHINA KANNADA, KARNATAKA



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भारतीय
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प्रस्तावना

मुझे काजू अनुसंधान निदेशालय, पुन्नूर, का वार्षिक प्रतिवेदन 2010-11 प्रस्तुत करने में खुशी होता है, जिसमें अप्रैल 2010 से मार्च 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 किये हैं और उत्तम पाये गये परिणामों तथा उपलब्धियों का इस वार्षिक प्रतिवेदन में प्रस्तुत की गई है। इस साल, चौदावें जीवनद्रव्य एक्सशनों को IPGRI वर्णकों के आधार पर मूल्यांकित करने से अब तक राष्ट्रीय काजू जीन बैंक (NCFGB) में संग्रहित 527 एकलशनों में से खुल मूल्यांकित एक्सशनों का संख्या 433 हुआ। सात साल का संघयी उपज के आधार पर हेब्रोडो: H-43, H-66, H-68, H-125 तथा H-126 क्रमशः 35.3, 34.6, 35.6, 37.6 तथा 34.4 कि.ग्रां./पेड संघयी उपज देकर उजाग रहा। जननद्रव्य एक्सशना को RAPD तथा ISSR मार्करो से आण्विक चरित्रवर्णन करने से लग भिन्नता पाया गया। Arc GIS से प्राप्त आकाशीय दलांश से काजू खेती के लिए सूका प्रदेशों का पता लगा सका। काजू का उत्पादकता 600 से 1500 मि.मी औसत वार्षिक बारिश पैलाव क्षेत्रों में अत्यधिक रहा। $ZnSO_4 + 0.1\%$ सालबोर + 0.5% $MgSO_4$ का पर्णोपसिंचन से उपचरित काजू पेडों में द्विलिंग पुष्प, पुष्पगुच्छ संख्या तथा गुटली संख्या, अनुपचरित पेडों की गुलना में ज्यादा रहा। प्याक्लोब्यूट्रल उपचरण प्रयोगों में पीध ऊँचाई, छा विस्तार तथा अन्तर पर्णसंधि का दूरी कम रहा। विविध कीटरोगजनक गोलकृमियों (Entomopathogenic Nematodes) में स्टीनरनीगा बैकलोरेटा इंडिका ने प्लोसीडेरस प्रभेधों को अत्यंत हनिकर लगा और हेटिरोसर्बेटिस इंडिका का प्रभाव व्याटोसेरा रूकोन्वाकुलेटा पर अत्यंत तीक्ष्ण था। इस साल काजू पारिस्थिति में चाय मच्छर का चार प्रभेध, यानि हेलोपेल्टीस आन्टनी हेलोपेल्टीस ब्राडी, हेलोपेल्टीस धीवोरा तथा प्याकिपेल्टीस गीसारग का सहासित्व पाया गया। कच्छ काजू गुटली सुखाने के लिये हवावाक प्रकार ड्रियर को निर्मित किया गया जिसमें ताजा काटित गुटली का नमी प्रमाण 2.5 से 3.0 घंटे में सुरक्षित नमी स्तर, यानि 8.0 प्रतिशत (वजन के आधार) तक लाया गया। कच्छ काजू गुटली संस्करण हेतु एक निरंतर ड्रग सेंकन मशीन का परिरूप तथा विकास किया गया।

इस निदेशालय में DCCD, कोच्यो और विकास विभागों से तांत्रिकी हस्तांतरण की मजभूत बनाने के लिये सहयोग चालू रहा। इस वर्ष दक्षिण कन्नडा, कर्नाटक में 16 प्रात्यक्षकी प्लाटो स्थापित की गयी है। वार्षिक काजू दिवस की सफलता पूर्वक आयोजित किया था जिसमें केरला तथा कर्नाटका के अधिकारियों ने शामिल थे। इस निदेशालय ने अनेक प्रदर्शनों में भाग लिया और CPCRI, कासरगोडु में दिनांक 25-28 अक्टूबर, 2011 को आयोजित "समृद्धि के लिये नारियल जीववैविध्यता" पर अंतर्राष्ट्रीय सम्मेलन में "अत्युत्तम स्टाली में एक" पुरस्कार प्राप्त किया।

मैं वर्ष 2010-11 का वार्षिक प्रतिवेदन को संकलन करने के लिये संपादकीय समिति के सदस्यों को आभारी हूँ।

एम. गोपालकृष्ण भट्ट

(एम. गोपालकृष्ण भट्ट)
निदेशक

स्थल : का. अ. नि., पुन्नूर
दिनांक : 13 जून, 2011

PREFACE

I am pleased to present the Annual Report 2010-11 of Directorate of Cashew Research, Puttur in which progress of the Directorate for the period from April 2010 to March 2011 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 and results of these projects are reported in this Annual Report.

During the year, fourteen germplasm accessions were characterized as per IPGRI descriptors bringing the total number of accessions evaluated to 433 out of 527 accessions maintained in National Cashew Field Gene Bank. The hybrids II-43, II-66, II-68, II-125 and II-126 continued to perform better with a cumulative nut yield of 35.3, 34.6, 35.6, 37.6 and 34.4 kg/tree, respectively for seven harvests. The molecular characterization of germplasm accessions using both RAPD and ISSR markers indicated existence of low diversity. Studies on the spatial data base using Arc GIS indicated the soils suitable for cashew cultivation. The productivity of cashew was highest in regions with a mean annual rainfall distribution of 600 to 1500 mm. Foliar spray of 0.5 per cent $ZnSO_4$ + 0.1 per cent solubor + 0.5 per cent $MgSO_4$ on cashew yielded more number of bisexual flowers, number of panicles and number of nuts per tree over control. Studies on application of paclobutrazol on cashew showed reduction in plant height, canopy spread and internodal length. Among the Entomo Pathogenic Nematodes (EPN) evaluated, *Steinernema bicoloratum indicum* was most virulent to *Platyedra* spp., while *Heterorhabditis indica* was most virulent to *Bactrocera reformaculata*. Co-existence of four species of tea mosquito bug viz., *Helopeltis antonii*, *H. bradyi*, *H. theivora* and *Pachypeltis maccartoni* was observed in cashew eco-system during the year. Dryer for raw cashewnuts with dual mode was fabricated in which freshly harvested nuts could be dried to safer moisture level i.e., 8 per cent d.b within a short period of 2.5 to 3 h. A continuous type compact drum roasting machine for raw cashewnuts was designed and developed.

The Directorate continued its collaboration with DCCD, Kochi, and Development Departments for strengthening the Transfer of Technology programmes. During the year, 16 demonstration plots were established in farmers' fields located in Dakshina Kannada district of Karnataka covering an area of 20 ha. The Directorate has successfully organized Annual Cashew Day and officials of Kerala and Karnataka participated actively in this programme. This Directorate had participated in several exhibitions and also bagged the prize as one of the best stalls in an exhibition organized at CPCRI, Kasaragod in the International Conference on Coconut Biodiversity for Prosperity held during 25-28 October, 2010.

I am thankful to members of Editorial Committee for compiling the Annual Report 2010-11.

Place : DCR, Puttur
Date : 13 June, 2011

(M. Gopalakrishna Bhat)
Director

कार्यकारी सारांश

काजू अनुसंधान निदेशालय में 2010-11 में, दो DBT परियोजनाएँ, एक NAIP परियोजना और एक जौंच परीक्षण सहित कुल मिलाकर 30 परियोजनाएँ थीं। इस साल, 1999-2000 रोपित चौदह जीवनद्रव्य एकसंशनों को मूल्यांकन तथा IPGRJ वर्णकों के आधार पर वर्धन, उपज व गुटली लक्षणों का चरित्रवर्णन करने से NCFGB में संरक्षित 527 एकसंशनों में 433 एकसंशनों का मूल्यांकन हुआ है। हैब्रिडो H-43, H-66, H-68, H-125 तथा H-126 क्रमशः 5.20, 6.25, 6.55, 5.95 और 5.70 कि.ग्रां / पेड़ का वार्षिक उपज और 35.33, 34.61, 35.55, 37.60 और 34.39 कि.ग्रां / पेड़ का सात साल का संवर्धी उपज दिया। इसी साल में RAPD और ISSR मार्कर के तहत 60 जीवनद्रव्य एकसंशनों का चरित्रवर्णन की गयी है। जकार्ड संगनरूप गुणांक संख्या (जकार्ड, 1908), दो एकसंशनों के बीच 0.58 से 0.89 तक रहा और औसत संगनरूपता 0.73 रहकर एकसंशनों के बीच का भिन्नता सूचित किया।

फरवरी और मार्च 2010 में, धन रोपण पद्धति (416 व 500 पेड़/हे) में पेड़ों का तल में नगी प्रमाण निचला परत (10 से 14.6% db) में साधारण रोपण पद्धति (200 पेड़/हे) (10 से 12.6% db) से अधिक रहा। धन रोपण प्लांटों में सावयव कार्बन प्रमाण अधिक था। Arc GIS तंत्रांश को इस्तेमाल करके गूदा, काजू (सर्वेक्षण आंकड़े), सतह ऊँचाई, औसत वार्षिक बारिश, कनिष्ठ तापमान और औसत वार्षिक तापमान का आकाशीय दत्तांश संग्रहित करके काजू क्षेत्र पैलाव पर अधिचित्र करके फसल सूकारा अध्ययन किया गया। साधारणतया काजू कृषि, लाल दुमटी व गहरला मिट्टी, मिश्र लाल व काला मिट्टी, तटीय और नदीमुखी कठारी मिट्टी में वितरित होता है। उत्पादकता 600-1500 मि.मि. औसत वार्षिक वर्ष पैलाव का जगह में अधिक रहा। जिस जगह में कनिष्ठ तापमान 10°C से 22°C तक रहा, काजू उत्पादकता उस जगह में अधिक रहा, पर 10°C से नीचे का कनिष्ठ तापमान का जगहों में कम रहा।

काजू का तीन विविध अवस्थाओं यानि, प्रक्षालन, पुष्पण और गुटली विकसन समय में 0.5% $ZnSO_4$ + 0.1% गालुवोर + 0.5% $MgSO_4$ का पर्णीय सिंचन से प्रति पेड़ में अधिक द्विलिंग पुष्प संख्या (20.2%), अधिक पुष्पगुच्छ संख्या (271), गुटली संख्या (202) था, जबकि

नियंत्रित प्लांटों में प्रति पेड़ में द्विलिंग पुष्प संख्या (13.1%) पुष्पगुच्छ संख्या (180) और गुटली संख्या (151) होकर कम रहा। पर्णीय सिंचन उपचरित सूची पत्ता (4 वा और 5 वा पक्का पत्ता) का नमूनाओं में खनिज पोषक का मात्रा पर्याप्त रूप से अनुपचरित पेड़ों से ज्यादा पाया गया। इससे पर्णीय पोषक सिंचन और पत्ताओं का खनिज मात्रा से घनात्मक संबंध प्रतिफलित था।

जैवउर्वरक उपयोग का विधान और उर्वरक मात्रा से गूदा सूक्ष्मीवि संख्या पर प्रभाव का अध्ययन से पता चला कि जैवउर्वरक संकाय (*जजोस्पैरिल्ला*, *असेटोब्याक्टर*, विलयशील बाक्टीरिया और जडसंयुक्त कवक जाल) को पेड़ कगार में 45 से.मी. त्रिज्य में डालने (50 ग्रां/पेड़) + चार पेड़ों के बीच में अयताकार खन्दक खोदकर जैवउर्वरक संकाय लगाने (50 ग्रां/पेड़) से बैकटीरिया संख्या (23.2×10^4 प्रति ग्रां), कवक संख्या (12.5×10^4 प्रति ग्रां), आक्विनेगैसीटीस संख्या (19.21×10^4 प्रति ग्रां), N-फिक्सर (4.28×10^4 प्रति ग्रां) और रंजक विलयशील को (5.89×10^4 प्रति ग्रां) इस अध्ययन का अन्य उपचारों की तुलना से अधिक दखिल हुआ। उर्वरक प्रमाण कुछ निश्चित वितरण रचना नहीं दिखाई। काजू को प्याक्लोव्यूट्रसाल (0.5, 1.0 और 1.5 a.i. /पेड़) का उपचार अध्ययनों में पेड़ों का वृद्धि कम रहा जिससे पेड़ ऊँचाई, छा विस्तार तथा अंतरापर्णसन्धि लम्बाई शामिल थे। प्याक्लोव्यूट्रसाल प्रयोग बड़ाने से कांड घेरा तथा प्ररोहों का संख्या भी बड़ा।

कृषि उपयोगी कीटों का राष्ट्रीय ब्यूरो (NBRI) बंगलूरु से प्राप्त तीन कीट रोगजनक गोलकृमि Entomopathogenic Nematodes (EPN) प्रभेध यानि, *स्टीनरनीमा बेंकलेटेा इंडिका*, *हेटीरोराब्डैटिस इंडिका* और *स्टीनरनीमा अब्बासी* को *फोसीडेरस* प्रभेधों तथा *ब्याटोसेरा लफौन्धाकुलेटा* काजू कांड और जड छेदक सूँडियों पर रोगकारक क्षमता के लिये परीक्षित किया गया। DCR का परीक्षण प्लांटों में अक्टोबर 2010 से फरवरी 2011 तक चाच मच्छर का चार प्रभेधों यानि, *हेलोपेल्टीस ऑन्टनी*, *हे. ब्राडी*, *हे. शीवीस* और *प्याकीपेल्टीस मीसुरम* का सहायित्व पाया गया।

इनमें, हेलोपेल्टीस ऑन्टनी और हे.ब्राडी प्रमुख प्रभेद थे। सभी अवलोकन राईनों में पूरा TMB संख्या में इन दो प्रभेदों मिलकर कुल संख्या में 50 प्रतिशत से ज्यादा रहा।

कच्चा काजू गुटली सुखाने के लिये द्रवात्मक ड्रयर (विद्युत तथा जैवईंधन आधारित) को निर्माण करके, DCR में स्थापित करके कार्यवाहित किया गया। ताजा काटीत गुटलीयों को 2.5 से 3.0 घंटों में 8.0 प्रतिशत सुरक्षित नमी (वजन आधार पर) तक सुख सका। निरंतर सधन सेंकन मशीन कच्चा काजू गुटली संकलन के लिये विन्यास किया गया और विकसित किया गया। सेंकन विशेषताओं का जाँच प्रयोगों में काजू गुटलीयों को 350°C से 450°C तक का तापमान में सेंकने से काजू गरी में प्रापित सफेदी सूचक (Whiteness Index) पाया गया।

वर्तमान साल में, 16 प्रदर्शनी प्लाटों को 20 हेक्टर विस्तार में कर्नाटका का दक्षिण कन्नडा जिला के पुत्तुर, बंटवाळा और सुळया में कृषकों का बगानों में लिया गया। इन प्लाटों को DCCD, कोच्ची का NHM कार्यक्रम का अंतर्गत वित्तीय सहायता से स्थापित हुआ। इन प्रदर्शनी

प्लाटों का शुरुवात में कृषकों को काजू किस्मों, धन सांभ रोपण और मृदा और जल संरक्षण के बारे में तकनीकी मार्गदर्शन दिया गया था। इस निदेशालय ने अनेक प्रदर्शनों में काजू अनुसंधान का विकास और उपलब्धियों की बारे में स्थल लगाकर बाग लिया। ICPCRA, कासरगोड में दिनांक 25-28 अक्टोबर 2010 में आयोजित नारियल में जीवविधता के बारे में अंतराष्ट्रीय सम्मेलन में "उत्तम स्थलों में एक" पुरस्कार पाया।

विविध संस्थानों के विनती के अनुसार इस निदेशालय का विज्ञानियों ने काजू उत्पादन तकनीके संबंधित तकनीके सलाह दिया। पुणे स्थित BARI-विकास अनुसंधान फौन्डेशन की आमंत्रण पर गुजरात और महाराष्ट्र का काजू बगानों को विज्ञानियों का एक टीम ने निरीक्षण किया। इस टीम ने कम उपज का वैज्ञानिक कारण को जाँच करके उसे संभाव्य स्तर को बढ़ाने के लिये सूक्त सलाह दिया। वर्तमान साल में लगभग दो लाख काजू फलमनों को कृषकों और विस्तार विभागों को वितरित किया। इस निदेशालय में प्रचलित अनुसंधान परियोजनाओं का परिणामों का विवरणों को इस वार्षिक प्रतिवेदन में प्रस्तुत किया है।



EXECUTIVE SUMMARY

A total of 381 projects including, two DBI projects, one NAITP project and one observational trial were in operation at Directorate of Cashew Research during 2010-11. During the year, fourteen germplasm accessions planted in 1999-2000 were evaluated and characterized as per IPGRI descriptors for their growth, yield and nut characters bringing the total number of accessions evaluated to 433 out of 527 accessions maintained in NCFGB. The hybrids under evaluation viz., H-43, H-66, H-68, H-125 and H-126 yielded 5.20, 6.25, 6.55, 5.95 and 5.70 kg/tree, respectively, with a cumulative yield of 35.33, 34.61, 35.55, 37.60 and 34.39 kg/tree, respectively, for seven harvests. During the year, 60 germplasm accessions were characterized using both RAPD and ISSR markers. The similarity co-efficient 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.

The soil moisture content at the base of the plant under high density planting (416 and 500 plants/ha), during February and March 2010 was higher in the lower layers (10 to 14.6 % dry basis) as compared to normal density planting system (200 plants/ha) (10 to 12.6% dry basis). Higher content of organic carbon was also recorded under high density planting plots than in normal density planting. The spatial data base of soil, cashew (survey data), surface elevation, mean annual rainfall, minimum temperature and mean annual temperature at country level was prepared using Arc GIS software and its overlay with cashew area distribution has been done for the crop suitability studies. Cashew is generally distributed along loamy red and laterite soil, mixed red and black soil, coastal and deltaic alluvium derived soil. The productivity was highest in region with a mean annual rainfall distribution of 600 to 1500 mm. The productivity of cashew was higher in regions where the minimum temperature ranged from 10°C to 22°C and was lower in regions where the minimum temperature drops below 10°C.

Foliar spray of 0.5 per cent $ZnSO_4$ + 0.1 per cent solubor + 0.5 per cent $MgSO_4$ on cashew at three different stages viz., flushing, flowering and nut development yielded the highest bisexual flowers (20.2%), panicles (271 nos) and nuts (202 nos) per tree over control (bisexual flowers: 13.1%, panicles: 180 nos and nuts: 151 nos per tree). Index leaves (4th and 5th matured leaves) sampled after foliar nutrition treatments showed appreciably higher content of mineral nutrients in foliar spray treated plants as compared to the untreated plants. These results reflect the positive relationship between the foliar application of nutrients and the minerals content of the leaves.

Studies on the effect of method of biofertilizer application and fertilizer levels on soil microbial population showed that combined application of biofertilizer consortia (*A. asperillum*, *Acetobacter*, Phosphate solubilizing bacteria and arbuscular mycorrhizal fungi) around tree basin to a radius of 45 cm (50 g each/tree) + inoculation in the rectangular trenches taken in the middle of four trees (50 g each/tree) resulted in a higher population of bacteria (23.2×10^7 g⁻¹), fungi (12.5×10^4 g⁻¹), actinomycetes (19.21×10^5 g⁻¹), N-fixers (4.28×10^5 g⁻¹), and P solubilizers (5.89×10^4 g⁻¹) compared to other treatments tested in this study. Fertilizer levels did not show any definite distribution pattern. Studies on application of paclobutrazol (0.5, 1.0 and 1.5 a.i./plant) on cashew showed reduction of growth of plants with respect to parameters like plant height, canopy spread and internodal length. The girth of the stem and number of flushes increased with the application of paclobutrazol.

Three different species of Entomo Pathogenic Nematodes (EPN) obtained from National Bureau of Agriculturally Important Insects (NBARI), Bangalore viz., *Steinernema bicolorata indica*, *Heterorhabditis indica* and *Steinernema abbasi* have been tested for their virulence on CSRB grubs of *Ploccaederus* spp. and *Batocera rufomaculata*. *Steinernema bicolorata indica* was most virulent to *Ploccaederus* spp., while *Heterorhabditis indica* was most virulent to *Batocera*

rajomaculata. Co-existence of four species of tea mosquito bug (TMB) viz., *Helopeltis antonii*, *H. bradyi*, *H. theivora* and *Pachypeltis maesarian* was observed during October 2010 to February 2011 in the experimental plots of DCR. Among these, *Helopeltis antonii* and *H. bradyi* were the dominant species. Both the species put together accounted for more than 50 per cent of the TMB population during all the months of observation.

Dryer for raw cashewnuts with dual mode (Electrical and biofuel power operated) was fabricated, installed and commissioned at DCR. Freshly harvested nuts could be dried to safer moisture level i.e., 8 per cent d.b within a short period of 2.5 to 3 h. A continuous type compact drum roasting machine for raw cashewnuts was designed and developed. Studies on roasting characteristics of raw cashewnuts indicated that raw cashewnuts exposed to temperature between 350-450°C yielded cashew kernels of desired whiteness index.

During the year, 16 demonstration plots were established in farmers' fields located in Puttur, Sullia and Banrwal taluks of Dakshina Kannada district of Karnataka covering an area of 20 ha. These plots were established with financial support of NHM

programme of DCCD, Kochi. Technical guidance on cashew varieties, high density planting and soil and water conservation techniques in cashew was provided to farmers while laying out these demonstration plots. This Directorate participated in several exhibitions by putting up stalls depicting developments and achievements in cashew research. This Directorate bagged the prize as one of the best stalls in exhibition organized at CPCRI, Kasaragod in the International Conference on Coconut Biodiversity for Prosperity during 25-28 October, 2010. As per the requests by various organizations, technical advice on cashew production technology was provided by Scientists of this Directorate. Cashew Day was organized on 1 March, 2011 in which more than 250 farmers participated. A team of Scientists visited the cashew plantations in Gujarat and Maharashtra on request from BAP Development Research Foundation, Pune. The team studied the scientific reasons for low yield and suggested measures to increase it to the potential levels. During the year, around two lakhs 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 initiated in the early 1950s. Indian Council of Agricultural Research (ICAR), sanctioned ad-hoc schemes for Research Centres located at Kottarakkara (Kerala), Ullal (Karnataka), Bapatla (Andhra Pradesh), Dargaoon (Assam) and Vengurla (Maharashtra). In 1971, ICAR also sanctioned All India Coordinated Spices and Cashew Improvement Project (AICS and CIP) with its Headquarters located at CPCRI, Kasaragod. The CPCRI Regional Station, Vittal (Karnataka) was given the mandate to carryout research work on cashew while four Centres under University (Bapatla, Vridhachalam, Anakayam and Vengurla) were assigned the research component on cashew under AICS and CIP. During the V and VI plan period three more Centres (Bhubaneswar, Jhargram and Chintamani) came under the fold of AICS and CIP and with stifling of work of Anakayam 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 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, 75.4° 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 1225 books and 1601 back volumes of various journals. The library subscribes 33 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 on 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 C o-operating Centres in Arabhavi (Karnataka), Old Goa (Goa) and Barapuni (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, brinjol, 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 P₂O₅ and 67.8 kg K₂O/ha. The yield of cashew increased by 50 per cent when glyricidia and seshania 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 biofertilizer (*Azospirillum* sp.) / 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 cres-cent 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. λ -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.
- Sweetened and flavoured spread could be prepared from cashew kernel baby bits. Cashew kernel baby bits could be coated with different combination 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 are 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 (2010-11)

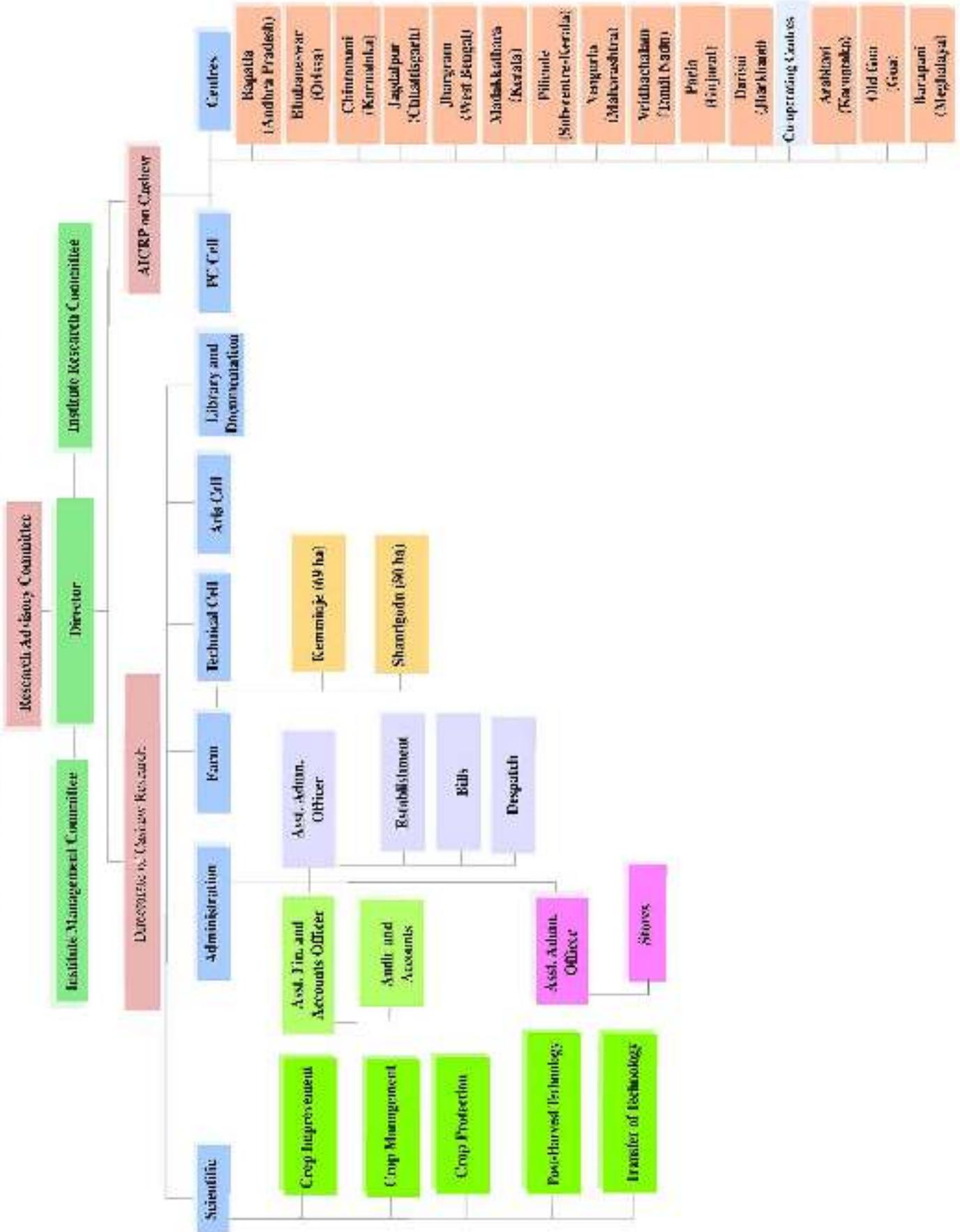
(Rs. In lakhs)

Plan	Non-Plan	External	Total
235.00	410.00	6.34	651.34

STAFF POSITION AS ON 31.3.2011

Category	Non-Plan		
	Sanctioned	Filled	Vacant
Director (RMP)	1	1	-
Scientific	18	11	7
Technical	19	18	1
Administrative	14	11	3
Skilled Supporting	39	35	4
Canteen	1	1	-
Total	92	77	15

ORGANIZATIONAL SETUP OF DCR, PUTTUR



RESEARCH ACHIEVEMENTS

1. CROP IMPROVEMENT

1.1 Genetic resources of cashew

1.1.1 Germplasm survey

A brief random germplasm survey was conducted in Dang, Navsari and Valsad districts of Gujarat, Nasik and Thane districts of Maharashtra and Cuddalore district (Vridhachalam) of Tamil Nadu for locating tolerant type to Tea Mosquito Bug (TMB) damage in seedling progeny orchards / isolated trees of cashew. Besides, plantations belonging to Karnataka Cashew Development Corporation (KCDC) in Dakshina Kannada and Uttara Kannada districts of Karnataka and in a few localities in and around Puttur were also surveyed. A few trees in Vridhachalam and KCDC plantations which have escaped the damage during the current fruiting season in severely damaged plots require further observation during next few years to confirm their tolerance to TMB damage, if any.

1.1.2 Germplasm evaluation

Fourteen germplasm accessions which were planted during the year 1999-2000 were evaluated as per IPGRI Descriptors for their growth, yield and nut characters and they were characterized (Table 1.1).

Among the 14 germplasm accessions evaluated, all had upright growing and majority (71%) had compact types with intensive branching habit. Majority (86%) had yellow red young leaves with club shape (79%). Majority (65%) were mid season and mid duration type of flowering and fruiting having medium size nuts with medium types attachment of nut to apple. The size of apple was big (85%) with medium nut to apple ratio (85%). Majority of the accessions (65%) had cylindrical apple shape with >50 per cent of them were red purple colour. All the accessions had intermediate shelling percentage, kernel weight and shell thickness with low cumulative yield.

Table 1.1: Important features of germplasm accessions evaluated during 2010

Data field	Descriptor	Descriptor State	No. of Accessions
7	Tree habit	3 Upright and compact	0
		5 Upright and open	14
		7 Spreading	0
9	Leaf shape	1 Oblong	0
		2 Obovate (Club-shaped)	11
		3 Oval	3
16	Branching pattern	1 Extensive	4
		2 Intensive	10
19	Colour of young leaves	1 Red	2
		2 Yellow Red	12
		3 Green Red	0
		4 Purple	0
28	Season of flowering	3 Early (Nov - Dec)	1
		5 Mid (Dec - Jan)	13
		7 Late (Jan - Feb)	0
31	Mature cashew apple colour	1 Yellow	4
		2 Yellow Red	3
		3 Red Purple	7
		4 Red Purple	0

32	Shape of cashew apple	1	Cylindrical	9
		2	Conical-Obovate	1
		3	Round	4
		4	Pyramidal	0
50	Attachment of nut to cashew apple	3	Loose	3
		5	Intermediate	7
		7	Tight	4
35	Nut weight	3	Low (<5 g)	0
		5	Intermediate (5-7 g)	9
		7	High (>7 g)	5
43	Weight of cashew apple	3	Low (<27 g)	0
		5	Medium (27-52 g)	1
		7	High (>52 g)	13
60	Flowering duration	3	Short (<60 days)	5
		5	Medium (60-90 days)	9
		7	Long (>90 days)	0
62	Apple nut ratio	3	Low (<6)	0
		5	Medium (6-12)	12
		7	High (>12)	2
63	Shelling percentage	3	Low (<18%)	0
		5	Intermediate (18-28%)	12
		7	High (>28%)	2
64	Kernel weight	3	Low (<1.2 g)	0
		5	Intermediate (1.2-2.5 g)	10
		7	High (>2.5 g)	4
57	Shell thickness	3	Thin (<2.5 mm)	1
		5	Intermediate (2.5-4.0 mm)	13
		7	Thick (>4.0 mm)	0
65	Attachment of peel to kernel	3	Loose	14
		7	Tight	0
68	Cumulative yield per plant (6 annual harvests)	3	Low (<9 kg)	14
		5	Medium (9-18 kg)	0
		7	High (>18 kg)	0

During the current fruiting season, 19 germplasm accessions which were planted during 2000-2001 were being evaluated as per IPCRI descriptors. The observations on growth and yield are completed and the observations on nut characteristics and shelling characteristics is under progress.

1.1.3 Germplasm conservation

Forty germplasm accessions evaluated during 2009-10 were vegetatively multiplied and planted in Conservation Block of National Cashew Field Gene Bank (NCFGB) at a closer spacing of 4m x 4m. The conservation block is being maintained by annual pruning and forcing the plant to remain as dwarf bush.

1.2 Genetic improvement of cashew for yield and quality traits

1.2.1 Evaluation of hybrids

The hybrids H-43, H-66, H-68, H-125 and H-126 yielded 5.20, 6.25, 6.55, 5.95 and 5.70 kg/tree, respectively with a cumulative yield of 35.33, 34.61, 35.55, 37.60 and 34.39 kg/tree, respectively for seven harvests (Table 1.2).

1.2.2 Seedling selection in cashew

An experiment was laid out in 2007 by planting the seedling progenies of NRCC Selection-2, Venguda-4, VRI-3, Bhaskara, VTH-174, and VTH-30/4 to find out the variability existing in cashew cultivars raised through seedlings. Growth parameters of these seedling progenies were recorded. The plant height ranged from 3.54 to 4.31 m. The stem girth ranged from 29.66 cm to 34.33 cm. The canopy spread ranged from 2.91 m to 3.87 m. The plant height was highest with seedling progenies of VTH-30/4, while canopy spread was highest with seedling progenies of VRI-3 (Table 1.3).

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

Hybrid	Cross combination	Annual yield in 7 th harvest (kg/tree)	Cumulative yield for 7 harvests (kg/tree)
H-43	NRCC Selection-2 x Bhathath-II	5.20	35.33
H-66	NRCC Selection-2 x Bhathath-II	6.25	34.61
H-68	NRCC Selection-2 x Bhathath-II	6.55	35.55
H-125	NRCC Selection-2 x Bhedasi	5.95	37.60
H-126	NRCC Selection-2 x Bhedasi	5.70	34.39

Table 1.3: Performance of seedling progenies for growth characters

Variety/Promising accession	Plant height (m)	Stem girth (cm)	Canopy spread (m)
NRCC Selection-2	3.54	30.25	3.21
V-4	3.89	29.66	2.91
VRI-3	3.53	33.58	3.87
Bhaskara	4.12	34.33	2.98
VTH-174	4.10	32.66	3.61
VTH-30/4	4.31	33.00	3.46

1.2.3 Performance of promising hybrids in replicated trial

The grafted plants of promising hybrids varied significantly for different growth parameters (Table 1.4). The average plant height ranged from 2.29 m to 4.52 m. The stem girth ranged from 20.69 cm to 35.86 cm. The canopy spread ranged from 2.62 m to 4.77 m. Variety Bhaskara (check) recorded highest plant height and stem girth, whereas, hybrid, H-68 recorded highest values for canopy spread.

1.3 Molecular characterization of cashew germplasm

During the year, 60 germplasm accessions were characterized using both RAPD and ISSR markers. In the P¹ set, thirty five accessions were characterized using 20 RAPD primers and 10 ISSR primers. RAPD and ISSR analysis was carried alone and in combination. By combining markers from both RAPD and ISSR a total of 226 bands were obtained, of which 128 were polymorphic (56.6%) with an average of 4.26 polymorphic bands/primer. The polymorphic information content (PIC) varied from 0.092-0.355 with an average of 0.216. Similarly, the Marker Index (MI) of primers varied from 0.184-2.208 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 are relatively divergent. Cluster analysis done grouped 35 accessions into 10 clusters (Fig. 1.1).

In another set, 25 germplasm accessions were characterized using RAPD and ISSR primers. RAPD analysis and ISSR analysis was carried out with 8 random primers and 9 primers respectively alone and in combination. 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.

Table 1.4 : Performance of promising hybrids in replicated trial

Hybrid/variety	Plant height (m)	Stem girth (cm)	Canopy spread (m)
H-43	3.18	25.51	3.56
H-66	2.85	28.38	3.30
H-68	3.95	29.80	4.77
H-125	3.21	26.61	4.26
H-126	3.67	24.40	3.84
H-1280	2.68	26.70	3.24
H-2452	2.29	20.69	2.62
H-2475	2.66	24.60	3.80
NRCC Selection-2 (check)	2.94	20.95	3.58
Bhaskara (check)	4.52	35.86	4.53
F-test	*	*	*
CD at 5%	0.84	11.86	1.48

1.4 Bulk segregant analysis

Based on the phenotypic evaluation, 16 DNA bulks for 8 economic characters were constituted in F_2 progeny of cross VRI 2 x VTH 711/4. Bulk segregant analysis was carried on these bulks using RAPD and ISSR markers. A total of 22 RAPD primers selected out of 100 UBC sequence primers by preliminary screening were used for screening bulks and observed of polymorphism in 8 primers. Similarly, by screening 28 selected ISSR primers on bulks only 7 primers were found polymorphic between bulks. Polymorphic markers could be recorded in bulks of fruiting laterals, plant height, TSS and shelling percentage. However, polymorphic markers recorded in bulks could not be substantiated with individuals of bulks.

1.5 Validation of markers identified

The four RAPD markers identified earlier in our study were validated using 177 individual plants of F_2 progeny of cross VRI-2 x VTH-711/4 and with 127 additional germplasm. The RAPD marker

identified for low nut weight designated as OPN 14₂₇₅ segregated in F_2 with presence of band in 74 and absent in 89 plants. Similarly the RAPD marker identified for both low nut weight and plant height designated as UBC 185₂₇₅ showed skewed segregation as only limited number of F_2 plants expressed the band. Another RAPD marker identified for high nut weight designated as UBC 184₂₇₅ was completely absent in F_2 indicating that there are no plants with high nut weight (>12.0 g). The deviation from the expected segregation in F_2 was probably due to insufficient segregation, population and phenotypic errors.

Similarly in germplasm, OPN 14₂₇₅ marker of low nut weight segregated with presence of band in 37 and absent in 90 plants. While the marker UBC 185₂₇₅ identified for both low nut weight and low plant height segregated with presence of band in 27 and absent in 100 plants. The low segregation of this band indicated rare occurrence of dwarfing in cashew. The marker for high nut weight i.e. UBC 184₂₇₅ was present in 33 and absent in 74 plants.

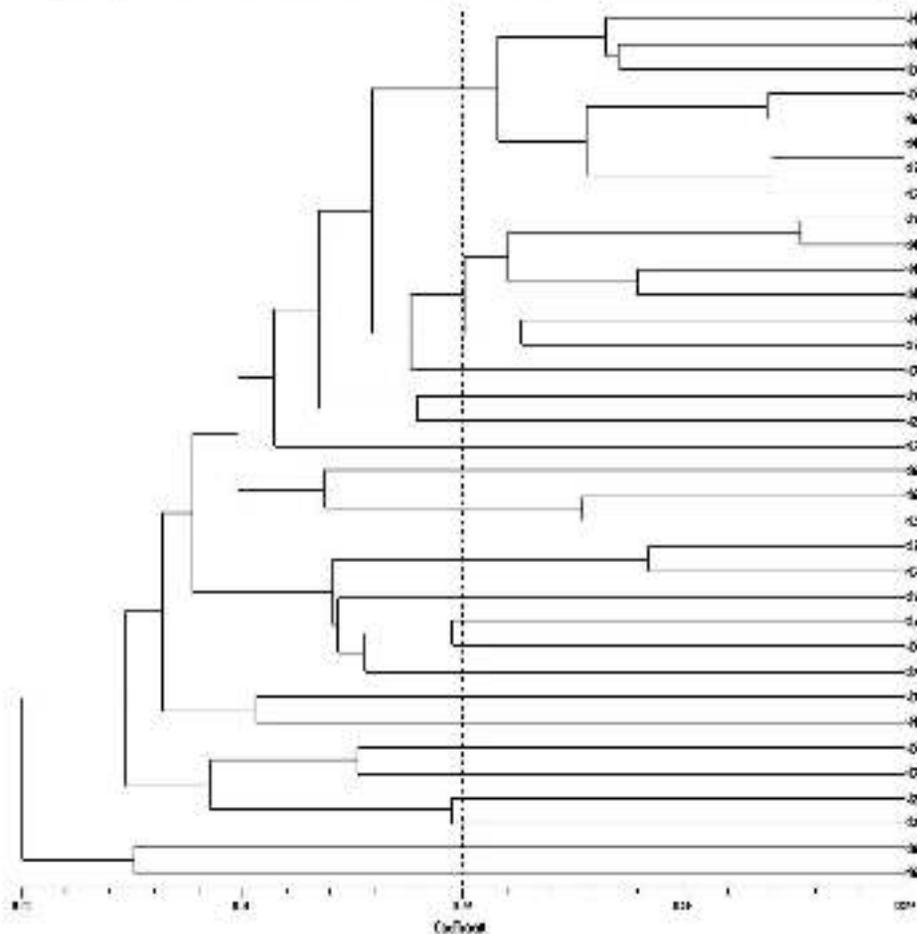


Fig. 1.1. Cluster of 35 accessions of cashew based on combined markers (RAPD + ISSR)

2. CROP MANAGEMENT

2.1 Nutrient requirement and pruning trials in high density plantation

An experiment was initiated in 2000 with 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 P₂O₅ and K₂O (M1), 150 kg N, 50 kg each of P₂O₅ and K₂O (M2), 225 kg N, 75 kg each of P₂O₅ and K₂O/ha (M3) as sub plot treatments to study the nutrient requirement unit area. The fertilizer treatments were imposed as per the recommended design and layout. The thinning of the alternate plants in half of the high density treatments were done in 2010.

2.1.1 Effect of tree density on yield and growth of cashew

The ground coverage in high density plots ranged from 95 to 100 per cent whereas in normal density it was 73 to 88 per cent and in thinned plots it was 63 to 78 per cent (Table 2.1 and 2.2). During 2009-10, the yield in the high density plots (416 and 500 trees/ha) was 12-15 per cent higher (2.19 and 2.43 t/ha) than in normal density plot (1.95 t/ha) nine years after planting. Increased manure dose from M1 to M3 had no significant difference in yield. No interaction effect of tree density and fertilizer levels was observed.

Table 2.1: Canopy coverage (%) in different treatment plots

Treatment (plants/ha)	M1	M2	M3	Mean
S1-200	79.0	88.0	73.0	80.0
S2-416	95.0	100.0	100.0	98.3
S3-500	100.0	100.0	100.0	100.0
Mean	91.3	96.0	91.0	
CD for main plot (p=0.05)				10.37
CD for sub plot (p=0.05)				NS

Table 2.2: Canopy coverage (%) in different treatment plots (thinned)

Treatment (plants/ha)	M1	M2	M3	Mean
S1-200	78.0	67.0	78.0	74.3
S2-416	68.0	63.0	78.0	69.7
S3-500	68.0	73.0	63.0	68.0
Mean	71.3	67.7	73.0	
CD for main plot (p=0.05)				NS
CD for sub plot (p=0.05)				NS

The higher cumulative nut yield (upto 10th year after planting) of 7.0 t/ha and 6.3 t/ha was obtained in high density plots of 500 and 416 plants/ha, respectively whereas in normal density it was only 5.2 t/ha (Table 2.3). Increased manure dose from M1 to M3 had no significant difference in yield. Interaction effect between tree density and fertilizer

levels was also not observed. The highest cumulative net profit of Rs. 1,67,002/ha (25% more than control) was obtained from the treatment of high density planting system (500 plants/ha) with lower fertilizer dose tested in this study and in normal density planting system with lower fertilizer dose, it was Rs. 1,34,012/ha (Table 2.4).

Table 2.3: Cumulative cashewnut yield (t/ha) under different fertilizer treatments and spacing (2003-10)

Treatment (plants/ha)	M1	M2	M3	Mean	% of control
S1-200	5.44	4.67	5.59	5.24	100
S2-416	5.62	6.40	6.84	6.29	120
S3-500	7.19	7.27	6.69	7.05	135
Mean	6.08	6.11	6.37		
CD (p = 0.05) - Main Plot				0.586	
CD (p = 0.05) - Sub Plot				NS	

Table 2.4: Cost of cultivation and net profit under different fertilizer treatments and spacing (2000-10) (Rs.)

	S1 M1	S2 M1	S3 M1	S1 M2	S2 M2	S3 M2	S1 M3	S2 M3	S3 M3
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	239148	216212	276730	179953	246269	279814	215296	263382	257157
Net profit	134012	116778	167032	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

2.1.2 Effect of high density planting system on soil moisture, available nutrients and leaf nutrient content

The soil moisture content at the base of the plant under high density planting (S2 and S3), during February and March 2010 was higher in the lower layers (10 to 14.5 % dry basis) as compared to normal density planting system (S1) (10 to 12.6% dry basis). The soil nutrient content (0-60 cm depth) in different treatments was determined at the end of harvesting period. Higher content of organic carbon was recorded under high density planting plots (S2 and S3) than in normal density planting. No specific trend was observed in P_2O_5 and K_2O content with respect to plant density and fertilizer dose. The organic carbon content in soil ranged from 0.35 to 0.55 per cent, available P_2O_5 content from 3 to 14 kg/ha, K_2O content from 88 to 419 kg/ha, Ca content from 390 to 708 kg/ha, Mg content from 5 to 40 kg/ha, Fe content from 42 to 70 ppm, Mn content from 45 to 83 ppm, Cu content from 0.43 to 0.98 ppm and Zn content from 7 to 17.5 ppm.

The nutrient content of the leaf showed that the P content ranged from 0.14 to 0.33 per cent, K content from 0.24 to 0.48 per cent, Ca content from 0.04 to 0.13 per cent, Na content from 0.13 to 0.21 per cent, Mg content from 0.008 to 0.013 per cent, Zn content from 12.2 to 33.9 ppm, Cu content from 4.3 to 8.9 ppm and Fe content from 37 to 50 ppm.

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

An experiment was laid out in 2006 with main

objective to determine optimum plant density for achieving highest yield and profit for the first ten years in different varieties so that the recommendation can go variety wise to achieve highest yield and net profit.

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 Selection-2, T3 : V-7, T4 : Ullal-1, T5 : Dhana, T6 : Madakkathara-2, T7 : Ullal-3, T8 : V-4 and T9 : Bhaskara.

Design: Split plot; Replications : 3; Plot size : 36 plants/main plot, 4 plants/sub plot.

2.2.1 Observations on growth and yield

After shape pruning, stem girth was more in varieties such as Ullal-3, Madakkathara-2, Bhaskara and Dhana (33.0 to 30.2 cm) (Table 2.5). The varieties like Madakkathara-2, Bhaskara, and Ullal-3 (380 to 387 cm) were taller than other varieties (Table 2.6). Different plant density did not have any significant effect on plant growth except for ground coverage by canopy. Variety Ullal-3 recorded highest ground coverage by the canopy (57.1%), while, VRI-3 recorded the least coverage by the canopy (31.4%) during 2010 (Table 2.7). With regard to yield per unit area, the highest yield in 2009-10 was recorded in the variety Ullal-3 (856 kg/ha). In general, varieties like Ullal-3, NRCC Selection-2, Ullal-1 and V-4 performed better than other varieties (Table 2.8).

Table 2.5 : Effect of plant density and varieties on the girth of stem (cm) five years after planting

Treatments-plants/ha	Girth of stem (cm) in different varieties									
	VRI-3	NRCC Sel-2	V-7	Ullal-1	Dhana	Madakka thara-2	Ullal-3	V-4	Bhaskara	Mean
S1-200	27.5	21.5	28.5	32.0	32.5	35.5	38.0	27.5	29.0	30.2
S2-236	22.5	27.5	27.0	28.5	30.0	30.0	29.0	31.5	28.0	28.2
S3-384	26.0	28.5	32.0	29.0	36.5	37.5	32.0	31.0	35.0	31.9
S4-500	23.5	23.5	29.0	25.5	27.5	29.0	32.0	27.0	29.0	27.3
Mean	24.8	25.3	29.1	29.1	31.6	33.0	32.8	29.2	30.2	
CD for main plot (p=0.05)										
CD for sub plot (p=0.05)										

Main plot = Plant density, Sub plot = Varieties

Table 2.6 : Effect of plant density and varieties on the height of plants (cm)

Treatments- plants/ha	Height of plants (cm) in different varieties									Mean
	VRI-3	NRCC Sel-2	V-7	Ullal-1	Dhana	Madakka thara-2	Ullal-3	V-4	Bhaskara	
S1-200	287	265	352	294	335	310	405	410	372	336.7
S2-312	185	305	326	347	350	390	375	405	378	340.1
S3-384	283	340	308	338	398	425	400	345	412	361.0
S4-500	280	325	369	298	285	395	368	340	375	337.2
Mean	259	309	339	319	347	380	387	375	384	
CD for main plot (p=0.05)										NS
CD for sub plot (p=0.05)										52.67

Main plot = Plant density, Sub plot = Varieties

Table 2.7 : Effect of plant density and varieties on the ground coverage by canopy (%)

Treatments- plants/ha	Ground coverage by canopy (%) in different varieties									Mean
	VRI-3	NRCC Sel-2	V-7	Ullal-1	Dhana	Madakka thara-2	Ullal-3	V-4	Bhaskara	
S1-200	17.3	16.1	26.5	18.9	17.8	19.2	23.9	14.8	16.6	19.0
S2-312	14.4	37.1	19.0	30.6	46.2	18.4	17.0	29.9	30.2	27.0
S3-384	15.5	36.0	32.4	28.1	30.0	29.2	20.5	41.4	32.2	30.6
S4-500	31.4	34.4	47.5	42.5	49.4	43.1	57.1	41.3	52.0	44.3
Mean	19.7	30.9	31.4	30.0	38.4	27.5	29.6	31.9	32.8	
CD for main plot (p=0.05)										7.90
CD for sub plot (p=0.05)										10.92

Main plot = Plant density, Sub plot = Varieties

Table 2.8 : Effect of plant density and varieties on the nut yield (kg/ha)

Treatments- plants/ha	Nut yield (kg/ha) in different varieties									Mean
	VRI-3	NRCC Sel-2	V-7	Ullal-1	Dhana	Madakka thara-2	Ullal-3	V-4	Bhaskara	
S1-200	181	142	129	161	149	102	447	256	397	218.2
S2-312	308	326	255	248	498	329	414	487	303	340.8
S3-384	648	1466	826	901	1175	584	972	751	1006	925.3
S4-500	454	879	315	104	354	285	1591	1205	858	671.6
Mean	397.7	703.2	381.2	680.5	541.0	300.0	856.0	674.7	641.0	
CD for main plot (p=0.05)										NS
CD for sub plot (p=0.05)										102.2

Main plot = Plant density, Sub plot = Varieties

2.3 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

2.3.1 Spatial data base

Elevation: The spatial data base of elevation of the DCR Farm and surrounding area was prepared using Arc GIS software. The topography of the selected area (elevation data from toposheets, Survey of India) was undulating with an elevation varying from 41 to 150 m above MSL with a downward slope towards Kinnaradhara river (Fig. 2.1).

Nutrient content: Soil samples (10 nos.) were collected from cashew plots in and around Purrur and were analysed for nutrients. The organic carbon content ranged from medium (0.50 to 0.56%) to high (0.95 to 0.99%). The available P₂O₅ content was found to be low (2.2 to 4.0 kg/ha). The available K₂O content of the soil in the upper layer (0-30 cm) ranged

from 53.4 to 107.4 kg/ha and in the lower layer (31-60 cm), it was 27.0 to 85.5 kg/ha. The Mg content in the upper layer ranged from 1.7 to 3.4 kg/ha whereas in the lower layer it was 1.7 to 3.14 kg/ha.

2.3.2 Spatial data base prepared using GIS and crop suitability studies for cashew

The spatial data base of soil, cashew (survey data), surface elevation, mean annual rainfall, minimum temperature and mean annual temperature at county 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

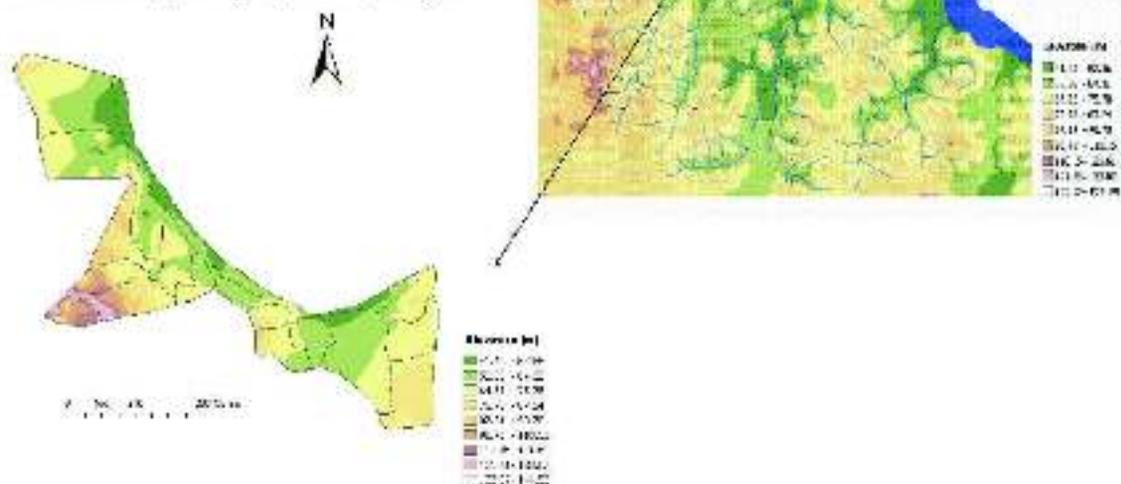


Fig. 2.1. The spatial data of elevation (DCR Farm and surrounding area)

derived soil. The elevation of the cashew growing areas ranged from 0 to 1000 m above mean sea level (MSL) and the productivity of cashew was higher in regions upto 750 m above MSL (Fig. 2.2). 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 of cashew was highest in regions with a mean annual rainfall distribution of 600 to 1500 mm (Fig. 2.3). 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 is higher in regions where the mean annual temperature ranged from 22.5 to 27.5°C (Fig. 2.4). 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.

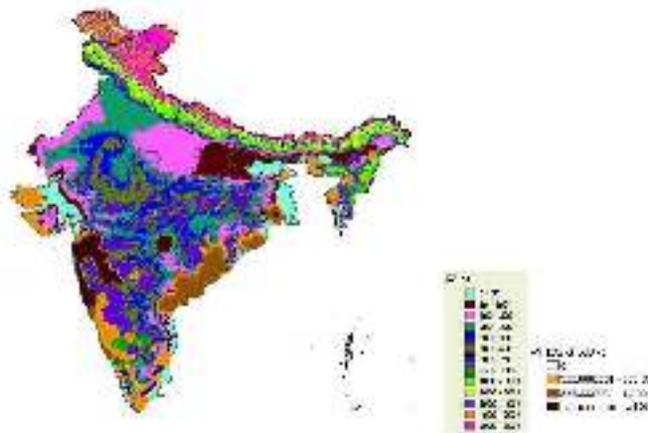


Fig. 2.2. Cashew area and productivity overlay with altitude above MSI.

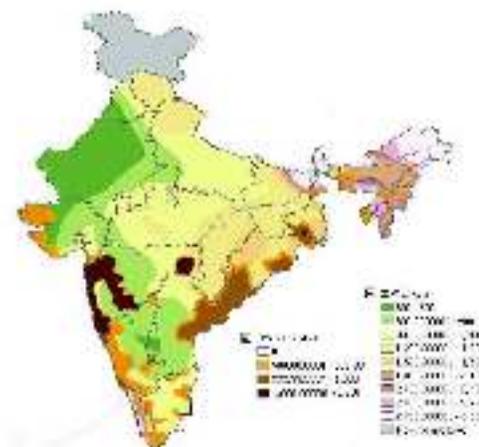


Fig. 2.3. Cashew area and productivity overlay with mean annual rainfall

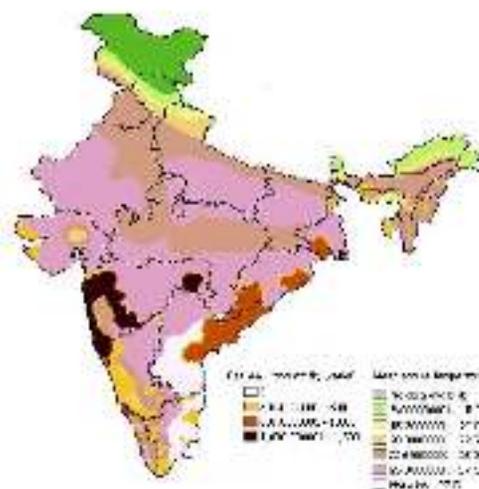


Fig. 2.4. Cashew area and productivity overlay with mean annual temperature

2.3.3 Remote sensing using ERDAS imagine

Two IRS P6 LISS IV MX images with a spatial resolution of 5.8 m were procured from NRSC, Hyderabad during 2010. Classification of images for determining the area under cashew, other vegetations, barren areas etc. have been done using Remote Sensing software, ERDAS Imagine. It was compared with the images obtained after classification of LISS III images. Among the two, LISS III image was better for identifying cashew vegetation. The images pertaining to the month of November is suitable for finding cashew since the colour of cashew leaves changes during that period.

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

Cashew grafts of Bhaskara variety raised in

the nursery with and without biofertilizer consortia (BFC) were transplanted in the field. Different biofertilizers and inorganic fertilizers as described below were applied to these grafts:

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 murate of potash/plant.

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

The experiment was laid out in RBD with three replications. There were six grafts in each treatment.

Five kg cattle manure/plant was applied uniformly to all the plants. The plants were spaced at 5m x 5m.

2.4.1 Effect of treatments on growth observations under field trial

The effect of biofertilizer consortia separately and in different combinations with chemical fertilizers on the growth of newly planted cashew grafts and resultant changes in soil microbial activity and nutrient content was assessed. All treatments increased the plant height of cashew grafts significantly at 11th and 14th months after planting compared to the untreated plants. Of the different treatments, the treatment 100% NPK + biofertilizer consortia resulted in the highest values in all growth parameters (Table 2.9).

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 (Tables 2.10, 2.11 and 2.12). 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 (Table 2.13).

Table 2.9: Effect of treatments on growth observations of cashew grafts under field trial

Treatment	Plant height (cm)		Stem girth (cm)		Canopy spread (cm)	
	11 MAP	14 MAP	11 MAP	14 MAP	11 MAP	14 MAP
Control	137.50	175.00	8.00	9.31	93.75	119.82
100% NPK	220.83	263.33	10.50	11.96	139.58	147.08
25% NP + 100% K + BFC	179.17	195.83	10.33	11.51	129.17	140.90
50% NP + 100% K + BFC	212.50	258.33	11.67	12.16	129.17	163.30
75% NP + 100% K + BFC	187.50	225.12	11.33	12.18	122.92	162.91
100% NPK + BFC	229.17	265.83	11.33	11.98	162.50	160.54
BFC alone	150.00	201.33	8.50	9.42	104.17	125.51
CD (p=0.05)	22.8	39.5	1.24	1.87	16.8	24.9

MAP = Months after planting

Table 2.10: Effect of treatments on soil nutrient status under field trial (4 months after planting)

Treatment	Organic carbon (%)		Available P (kg ha ⁻¹)		Available K (kg ha ⁻¹)		Exch. Ca (mg kg ⁻¹)		Exch. Mg (mg kg ⁻¹)	
	0-30 cm	31-60 cm	0-30 cm	31-60 cm	0-30 cm	31-60 cm	0-30 cm	31-60 cm	0-30 cm	31-60 cm
Control	0.77	0.46	15.5	6.4	185.6	150.2	304.5	259.8	61.8	46.9
100% NPK	0.78	0.39	16.5	8.9	220.8	148.5	310.2	255.3	73.6	43.2
25% NP + 100% K + BFC	0.84	0.47	17.2	9.1	225.0	159.5	300.6	270.3	78.9	54.8
50% NP + 100% K + BFC	0.88	0.52	18.2	8.8	216.5	166.2	318.5	286.1	70.4	59.6
75% NP + 100% K + BFC	0.80	0.55	18.1	9.3	221.4	140.3	295.6	214.7	80.2	65.5
100% NPK + BFC	0.82	0.57	20.3	7.9	228.6	150.9	320.5	248.5	75.5	55.0
BFC alone	0.80	0.50	16.9	8.1	196.8	145.6	315.6	210.6	74.2	60.2
CD (p=0.05)	0.10	0.07	3.4	2.6	21.1	15.0	ns	32.9	14.7	9.8

Table 2.11: Effect of treatments on soil nutrient status under field trial (4 months after planting)

Treatment	DTPA-Fe (mg kg ⁻¹)		DTPA-Mn (mg kg ⁻¹)		DTPA-Zn (mg kg ⁻¹)		DTPA-Cu (mg kg ⁻¹)	
	0-30 cm	31-60 cm						
Control	25.6	8.3	8.7	4.0	0.48	0.40	0.52	0.40
100% NPK	29.6	9.0	8.9	4.7	0.45	0.47	0.60	0.52
25% NP + 100% K + BFC	34.5	10.6	11.2	4.9	0.52	0.42	0.55	0.56
50% NP + 100% K + BFC	28.9	13.2	10.9	6.3	0.47	0.55	0.48	0.50
75% NP + 100% K + BFC	33.9	11.2	9.8	5.8	0.45	0.38	0.56	0.49
100% NPK + BFC	30.5	8.8	9.4	6.1	0.50	0.45	0.41	0.45
BFC alone	27.6	9.6	10.1	5.0	0.45	0.46	0.52	0.50
CD (p=0.05)	5.21	2.25	1.88	0.93	ns	ns	0.10	0.11

Table 2.12: Effect of treatments on soil microbial population and dehydrogenase activity (4 months after planting)

Treatment	Bacteria $\times 10^7 \text{ g}^{-1}$	Fungi $\times 10^4 \text{ g}^{-1}$	Actinomyceetes $\times 10^7 \text{ g}^{-1}$	N-fixers $\times 10^4 \text{ g}^{-1}$	P-solubilizers $\times 10^3 \text{ g}^{-1}$	Dehydrogenase activity ($\mu\text{gTPF/g dry soil/24 h}$)
Control	30.65	31.52	34.20	13.56	12.56	23.60
100% NPK	33.93	39.35	32.65	12.00	10.59	24.85
25% NP + 100% K + BFC	43.51	50.26	43.58	18.50	16.20	35.92
50% NP + 100% K + BFC	74.24	42.38	35.61	16.14	14.32	26.90
75% NP + 100% K + BFC	56.30	33.69	36.80	11.59	11.90	28.90
100% NPK + BFC	45.38	21.25	37.50	12.79	8.89	27.50
BFC alone	42.61	43.91	49.25	19.59	18.77	32.65
CD ($p=0.05$)	6.21	4.89	3.12	2.05	1.78	3.35

Table 2.13: Effect of treatments on leaf nutrient content (4 months after planting)

Treatment	N (%)	P (%)	K (%)
Control	1.65	0.18	0.81
100% NPK	1.85	0.18	0.88
25% NP + 100% K + BFC	1.73	0.21	0.89
50% NP + 100% K + BFC	1.86	0.20	0.88
75% NP + 100% K + BFC	1.85	0.22	0.90
100% NPK + BFC	1.89	0.22	0.98
BFC alone	1.70	0.18	0.79
CD ($p=0.05$)	0.22	0.03	0.12

2.5 Effect of foliar application of nutrients on growth, fruit set, yield and quality of cashew

A field experiment was initiated in 2009 to investigate the effect of foliar application of nutrients on nine year old cashew trees (NRCC Selection-2). Two experiments were laid out in a randomized block design with three replications. Foliar spray was given at three different stages viz., flushing, flowering and nut development. The treatment details are given below:

Experiment I: Foliar spray of major nutrients on cashew

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

Experiment II: Foliar spray of secondary and micronutrients on cashew

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

2.5.1 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. No significant difference in soil analysis data was found between foliar spray treated plants and untreated plants. The soil pH varied from 5.62 to 6.05 (Experiment I) and 5.94 to 6.11 (Experiment II), EC 0.022 to 0.033 $d Sm^{-1}$ (Experiment I) and 0.027 to 0.035 $d Sm^{-1}$ (Experiment II), organic carbon 8.0 to 8.4 $g kg^{-1}$

(Experiment I) and 8.8 to 9.1 $g kg^{-1}$ (Experiment II), available N 151.8 to 182.3 $kg ha^{-1}$ (Experiment I) and 180.4 to 206.7 $kg ha^{-1}$ (Experiment II), available P 16.3 to 19.2 $kg ha^{-1}$ (Experiment I) and 17.9 to 20.45 $kg ha^{-1}$ (Experiment II) and available K 130.5 to 146.3 $kg ha^{-1}$ (Experiment I) and 137.2 to 150.1 $kg ha^{-1}$ (Experiment II). The available Fe varied from 33.9 to 40.2 $mg kg^{-1}$ (Experiment I) and 35.8 to 42.9 $mg kg^{-1}$ (Experiment II), available Mn 20.6 to 26.3 $mg kg^{-1}$ (Experiment I) and 27.2 to 31.3 $mg kg^{-1}$ (Experiment II), available Zn 0.20 to 0.28 $mg kg^{-1}$ (Experiment I) and 0.26 to 0.33 $mg kg^{-1}$ (Experiment II), and available Cu 0.70 to 0.76 $mg kg^{-1}$ (Experiment I) and 0.55 to 0.64 $mg kg^{-1}$ (Experiment II).

2.5.2 Effect of foliar spray of nutrients on leaf nutrient content, yield attributes and quality of cashew

Index leaves (4th and 5th matured leaves) sampled after foliar nutrition treatments were analysed for their nutrient contents. The minerals content of the leaves were appreciably higher in foliar spray treated plants as compared to the untreated plants. These results reflect the positive relationship between the foliar application of nutrients and the minerals content of the leaves. The N content ranged from 1.54 to 1.96 per cent (Experiment I) and 1.60 to 1.92 per cent (Experiment II), P: 0.12 to 0.23 per cent (Experiment I) and 0.14 to 0.23 per cent (Experiment II), K: 0.70 to 0.95 per cent (Experiment I) and 0.72 to 0.88 per cent (Experiment II), Fe: 32.6 to 39.1 ppm (Experiment I) and 35.9 to 44.5 ppm (Experiment II), Mn: 19.0 to 27.0 ppm (Experiment I) and 23.1 to 30.4 ppm (Experiment II), Zn: 13.3 to 17.9 ppm (Experiment I) and 15.5 to 23.2 ppm (Experiment II) and, Cu: 9.6 to 12.0 ppm (Experiment I) and 9.3 to 14.9 ppm (Experiment II) (Table 2.14 and 2.15).

The number of male and hermaphrodite (bisexual) flowers opened were recorded once in every two days upto the completion of flowering. Four trees were selected from each treatment. Four panicles, one in each direction was tagged before the commencement of flower opening. The data clearly showed a considerable improvement in the hermaphrodite flowers as a result of foliar spray of major as well as secondary and micronutrients. Foliar spraying of cashew plants with different concentration of major (Experiment I) and secondary

and micronutrients (Experiment II) increased significantly the bisexual flowers compared to the untreated plants. Of the major nutrients, the highest values were obtained by application of 0.5% H_2PO_4 + 1% K_2SO_4 (17.3%) followed by 0.5% H_2PO_4 (17.4%). In case of secondary and micronutrients, the highest values were obtained by application of 0.5% ZnSO_4 + 0.1% solubor + 0.5% MgSO_4 (20.2%) followed by 0.5% ZnSO_4 + 0.1% solubor (18.8%) (Fig. 2.5 and 2.6). Similarly, foliar spray of secondary and micronutrients significantly increased the number of panicles / tree and number of nuts / tree compared to untreated plants. The number of panicles

/ tree (271) and number of nuts / tree (202) were considerably higher in 0.5% ZnSO_4 + 0.1% solubor + 0.5% MgSO_4 foliar spray treated plants compared to other treatments tested in this study (Table 2.16 and 2.17). There was no significant difference in the number of panicles / tree and number of nuts / tree among the foliar spray of major nutrients.

Defatted cashew kernel was analysed for protein, sugars and starch. There was no significant difference in the protein (34.9 to 39.6%), starch (35.4 to 40.9 mg/100 g) and sugar (9.78 to 10.51 mg/100 g) content of the defatted kernel of cashew among the foliar sprayed and untreated plants.

Table 2.14: Leaf nutrient content as affected by foliar spray of major nutrients

Treatment	N (%)	P (%)	K (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)
Urea (3%)	1.96	0.17	0.84	34.2	21.9	15.2	10.1
H_2PO_4 (0.5%)	1.76	0.22	0.75	36.8	24.2	17.1	10.3
K_2SO_4 (1%)	1.75	0.18	0.95	35.0	26.0	16.0	10.9
Urea + H_2PO_4	1.90	0.20	0.78	37.8	23.4	17.5	10.5
Urea + K_2SO_4	1.85	0.19	0.89	36.9	26.5	17.2	11.2
H_2PO_4 + K_2SO_4	1.76	0.20	0.84	37.4	26.8	17.0	12.0
Urea + H_2PO_4 + K_2SO_4	1.92	0.23	0.95	39.1	27.0	17.9	11.6
Control	1.54	0.12	0.70	32.6	19.0	13.3	9.6

Table 2.15: Leaf nutrient content as affected by foliar spray of secondary and micronutrients

Treatment	N (%)	P (%)	K (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)
ZnSO_4 (0.5%)	1.76	0.18	0.81	39.0	26.5	23.0	10.8
Solubor (0.1%)	1.77	0.21	0.75	37.3	25.9	18.6	11.2
MgSO_4 (0.5%)	1.71	0.17	0.81	39.5	27.3	17.5	12.4
ZnSO_4 + Solubor	1.92	0.20	0.88	41.8	30.4	23.0	14.9
ZnSO_4 + MgSO_4	1.84	0.22	0.85	42.4	28.0	22.4	12.0
Solubor + MgSO_4	1.89	0.19	0.86	42.0	27.3	18.1	12.4
ZnSO_4 + MgSO_4 + Solubor	1.91	0.23	0.85	44.5	30.2	23.2	13.5
Control	1.60	0.14	0.72	35.9	23.1	15.5	9.3

Table 2.16: Yield attributes of cashew as affected by foliar spray of major nutrients

Treatment	No. of panicles/tree	No. of nuts/tree
Urea (3%)	186	160
H ₃ PO ₄ (0.5%)	187	165
K ₂ SO ₄ (1%)	182	160
Urea + H ₃ PO ₄	185	169
Urea + K ₂ SO ₄	192	172
H ₃ PO ₄ + K ₂ SO ₄	197	176
Urea + H ₃ PO ₄ + K ₂ SO ₄	202	180
Control	165	150
CD (p = 0.05)	20.51	20.13

Table 2.17: Yield attributes of cashew as affected by foliar spray of secondary and micronutrients

Treatment	No. of panicles/tree	No. of nuts/tree
ZnSO ₄ (0.5%)	202	174
Solubor (0.1%)	232	176
MgSO ₄ (0.5%)	216	164
ZnSO ₄ + Solubor	268	195
ZnSO ₄ + MgSO ₄	239	186
Solubor + MgSO ₄	224	178
ZnSO ₄ + MgSO ₄ + Solubor	271	202
Control	160	151
CD (p = 0.05)	23.89	22.77

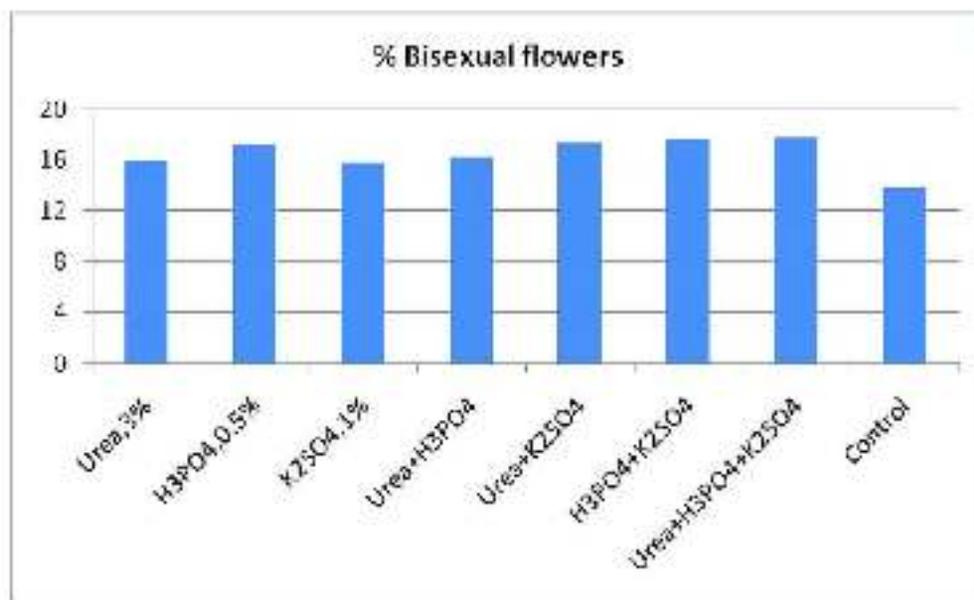


Fig. 2.5. Effect of foliar spray of major nutrients on bisexual flowers

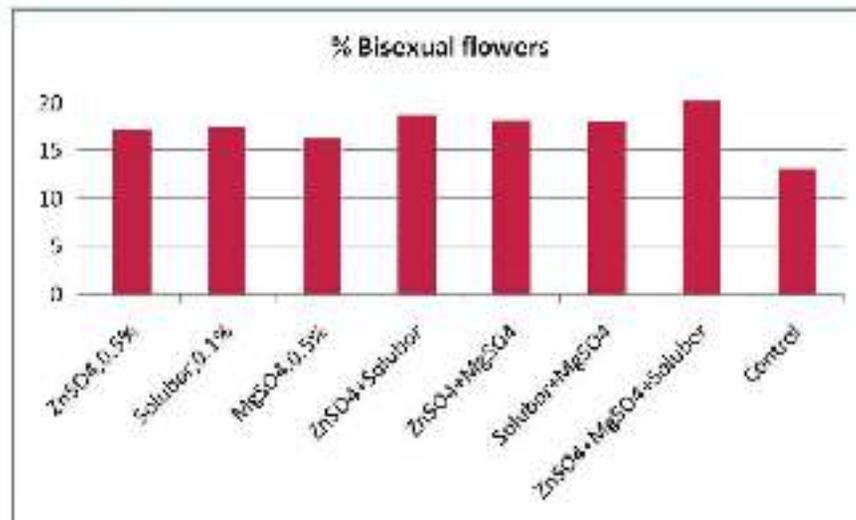


Fig. 2.6 Effect of foliar spray of secondary and micronutrients on bisexual flowers

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

The objective of the experiment was to develop a package of recommendation for young (Experiment 1: Two years old cashew variety VRI-3) and mature (Experiment 2: Nine years old cashew variety Bhaskara) cashew plantations involving integrated nutrient management (INM) with the application of biofertilizers, organic manures and chemical fertilizers.

Design	:	split plot
Replications	:	3
Spacing	:	7m x 4m
Number of plants/treatment	:	4

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

- M1: Control (No inoculation)
- M2: Biofertilizer (*Azospirillum*, *Acetobacter*, Phosphate solubilizing bacteria and AMF 50 g each/tree) inoculation around tree basin to a radius of 45 cm
- M3: Biofertilizer (*Azospirillum*, *Acetobacter*, Phosphate solubilizing bacteria and AMF 50 g each/tree) inoculation in the rectangular trenches taken in the middle of four trees
- M4: Combination of M₂ – M₃

(b) Sub plot treatments (Fertilizer levels)

- T1: Control (No application)
- T2: 50 % of recommended NPK through drip + FYM
- T3: 75 % of recommended NPK through drip + FYM
- T4: *100 % of recommended NPK through drip – FYM
- T5: Soil test based fertiliser recommendation through drip

*100 % of recommended dose: Urea 100 kg, DAP 30 kg, MOP 20 kg and FYM 2 t per ha per annum (N 135 g : P₂O₅ 39 g : K₂O 34 g and FYM 5.6 kg per tree per annum).

2.6.1 Effect of INM treatments on soil properties and nutrient content of index leaf

Profile soil sampling was done by collecting soil samples 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 in the 2nd year experiment. The soils were analysed for pH, EC, organic carbon, available N, P, K, Fe, Mn, Zn and Cu contents. Enumerated soil microbial population under different treatments. Of the different levels of fertilizer treatments (sub plots), 100% of recommended NPK through drip + FYM and soil test based fertiliser recommendation through drip were at par with respect to available nutrient content in the soil. Among the method of biofertilizer application (main plots), the maximum accumulation

of available nutrients was noted in the combined application of biofertilizer consortia (*Azospirillum*, *Acetobacter*, Phosphate solubilizing bacteria and AMF) around tree basin to a radius of 45 cm (50 g each/tree) + inoculation in the rectangular trenches taken in the middle of four trees (50 g each/tree) in both the experiments. The surface soil pH varied from 5.49 to 5.82, EC: 0.028 to 0.040 d Sm⁻¹, organic carbon: 11.0 to 11.9 g kg⁻¹, available N: 290.7 to 344.7 kg ha⁻¹, available P: 18.5 to 21.0 kg ha⁻¹ and available K: 154.5 to 180.3 kg ha⁻¹. Available Fe, Mn, Zn and Cu varied from 100.3 to 138.5 mg/kg, 9.8 to 14.2 mg/kg, 0.40 to 0.67 mg/kg and 0.70 to 0.95 mg/kg, respectively. A consistent decrease in the contents of available nutrients with the increase in soil depth was noted.

The size of the microbial population in soil varied considerably with the method of biofertilizer application. Among the method of biofertilizer application, combined application of biofertilizer consortia around tree basin to a radius of 45 cm (50 g each/tree) + inoculation in the rectangular trenches taken in the middle of four trees (50 g each/tree) resulted in a higher population of bacteria (23.2×10^7 g⁻¹), fungi (12.5×10^7 g⁻¹), actinomycetes (19.21×10^7 g⁻¹), N-fixers (4.28×10^7 g⁻¹), and P solubilizers (5.89×10^7 g⁻¹) compared to other treatments. Fertilizer levels did not show any definite distribution pattern.

The mean monthly (January to March) soil moisture content was recorded at different depths in fertigation plots and control plots using TDR soil moisture profiling system during January to March 2011. The mean monthly soil moisture content was appreciably higher in drip irrigated plots [19.2 and 19.9 per cent dry basis (Experiment 1: young cashew plantation) and 18.2 and 23.3 per cent dry basis (Experiment 2: matured cashew plantation)]. The corresponding values in soil moisture content was very low in control plots (11.6 to 12.9 per cent in young cashew plantation and 10.3 to 12.0 per cent in matured cashew plantation).

The effect of INM treatments on the concentration of N, P, K, Fe, Mn, Zn and Cu in index leaves (4th and 5th matured leaves) was assessed. The concentration of nutrients was significantly higher

in INM treated plants than those found in untreated plants. Among the method of biofertilizer application, biofertilizer inoculation around tree basin to a radius of 45 cm and combined application of biofertilizer consortia around tree basin to a radius of 45 cm (50 g each/tree) + inoculation in the rectangular trenches taken in the middle of four trees (50 g each/tree) were at par with respect to leaf nutrient concentration. There was not much variation in leaf nutrient content between the treatments 100 % of recommended NPK through drip + FYM and soil test based fertiliser recommendation through drip. The concentration of nutrients in index leaves ranged from N: 1.48 to 1.81 per cent, P: 0.11 to 0.19 per cent, K: 0.68 to 0.87 per cent, Fe: 33.3 to 42.7 ppm, Mn: 23.8 to 31.5 ppm, Zn: 18.3 to 23.4 ppm and Cu: 10.5 to 14.0 ppm. Similar trend was observed in mature cashew plantation (Table 2.18 and 2.19).

2.6.2 Effect of INM treatments on growth, yield attributes and quality of kernel

The effect of method of biofertilizer application and fertilizer levels was investigated on growth and yield attributes of cashew. The various treatments had a significant influence on growth parameters of cashew only on young cashew plantation (Experiment 1). Tree height, trunk girth and canopy spread were significantly higher in INM treated plants compared to untreated plants in young cashew plantation. The growth parameters of cashew did not differ significantly among the treatments in mature cashew plantation (Experiment 2). The average plant height ranged from 310 to 365 cm (Expt. 1) and 752 to 910 cm (Expt. 2). The trunk girth ranged from 33.5 to 39.5 cm (Expt. 1) and 65.7 to 81.0 cm (Expt. 2). The canopy spread ranged from 365 to 410 cm (Expt. 1) and 710 to 800 cm (Expt. 2) (Table 2.20 and 2.21). The number of panicles/tree and nuts produced/tree was found to be significantly increased due to biofertilizer and different levels of fertilizer application. Among the treatments, combined application of biofertilizers around tree basin to a radius of 45 cm (50 g each/tree) and inoculation in the rectangular trenches taken in the middle of four

trees (50 g each/tree) and 100 % of recommended NPK through drip + FYM were found to be effective. Method of biofertilizer application and fertilizer levels did not produce significant difference in the

quality of cashew kernel. The protein, starch and sugar content of the defatted cashew kernel ranged from 36.5 to 39.2 per cent, 34.7 to 39.5 mg/100 g and 9.94 to 10.21 mg/100 g, respectively.

Table 2.18: Integrated nutrient management treatment effects on major nutrient content of index leaf of cashew variety VRI-3 (young cashew plantation) (2nd year experiment)

Treatment	N (%)					P (%)					K (%)				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
M1	1.48	1.56	1.57	1.66	1.60	0.11	0.11	0.13	0.14	0.14	0.68	0.74	0.74	0.81	0.80
M2	1.69	1.74	1.75	1.81	1.78	0.14	0.16	0.16	0.19	0.18	0.70	0.76	0.80	0.87	0.84
M3	1.53	1.55	1.64	1.70	1.75	0.12	0.14	0.14	0.16	0.16	0.68	0.70	0.78	0.81	0.81
M4	1.60	1.60	1.68	1.74	1.80	0.14	0.16	0.17	0.19	0.18	0.72	0.75	0.81	0.86	0.86

Table 2.19: Integrated nutrient management treatment effects on micronutrient content of index leaf of cashew variety VRI-3 (young cashew plantation) (2nd year experiment)

Treatment	Fe (ppm)					Mn (ppm)					Zn (ppm)					Cu (ppm)				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
M1	33.3	34.0	34.3	35.0	30.3	23.0	24.0	27.0	27.9	28.0	18.3	18.5	18.5	19.0	19.2	10.6	10.9	10.8	11.0	11.0
M2	34.5	35.8	38.1	42.7	40.8	25.0	28.4	30.3	31.5	30.5	18.8	22.4	22.4	23.0	21.9	11.5	13.1	13.2	14.0	14.0
M3	34.0	36.0	39.2	40.8	41.2	23.8	25.5	25.5	28.5	28.3	18.4	18.6	18.6	21.5	20.1	10.5	10.8	11.3	12.8	12.2
M4	34.5	39.2	40.8	42.5	42.0	24.5	24.5	27.9	30.9	31.5	18.8	19.2	21.8	23.4	23.0	12.2	12.9	13.2	14.0	13.8

Table 2.20: Integrated nutrient management treatment effects on growth of cashew variety VRI-3 (young cashew plantation) (2nd year experiment)

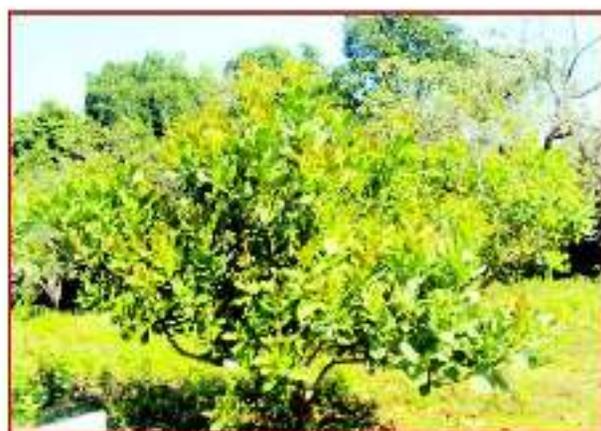
Treatment	Plant height (cm)						Girth (cm)						Canopy spread (cm)					
	T1	T2	T3	T4	T5	Mean	T1	T2	T3	T4	T5	Mean	T1	T2	T3	T4	T5	Mean
M1	318	315	312	328	320	321	33.9	34.6	36.3	35.2	33	34.6	365	371	382	380	377	375
M2	310	324	329	355	360	336	33.5	34.3	35.3	39.1	37.5	35.9	374	380	384	390	408	387
M3	325	324	331	342	308	326	34	34.8	36.1	36.9	35.2	35.4	369	376	384	390	382	380
M4	330	327	345	365	363	346	36.1	38.4	38.2	39.5	39.2	38.38	370	390	386	410	395	390
Mean	321	323	329	348	340		34.4	35.5	36.5	37.7	36.2		370	379	384	393	391	
CD (p=0.05)	Main plot					4.73						5.66						8.68
	subplot					16.74						4.51						9.46
	Main x subplot					ns						ns						ns

Table 2.21: Integrated nutrient management treatment effects on growth of cashew variety Bhaskara (mature cashew plantation) (2nd year experiment)

Treatment	Plant height (cm)						Girth (cm)						Canopy spread (cm)					
	T1	T2	T3	T4	T5	Mean	T1	T2	T3	T4	T5	Mean	T1	T2	T3	T4	T5	Mean
M1	845	822	825	790	831	823	72.5	70.0	70.5	77.0	74.0	72.8	725	720	790	750	800	757
M2	822	785	770	795	805	795	71.0	76.0	71.5	72.5	80.0	74.2	750	730	790	820	790	776
M3	850	760	900	815	880	841	67.5	69.0	69.0	67.0	71.0	68.7	720	730	740	820	725	747
M4	800	825	840	820	900	837	71.5	73.1	68.0	74.0	72.0	71.72	728	800	770	730	740	754
Mean	829	798	834	805	854		70.62	72.0	69.8	72.6	74.3		731	745	773	780	764	
CD (p=0.05)	ns						ns						ns					

2.7 Rootstock studies in cashew

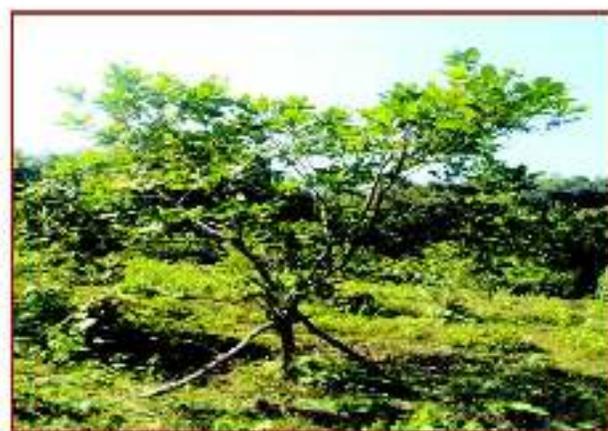
The different stionic combinations planted in the field were compared for various growth parameters. The various stionic combinations varied with respect to plant height and number of leaves per shoot. The plant height ranged from 1.86 m to 3.40 m. NRCC Selection-2 on Taliparamba-1 rootstock recorded the least plant height. The number of leaves per shoot ranged from 9.92 to 13.72. The girth below the graft union and girth above the graft union as well as the canopy spread did not vary among different stionic combinations (Table 2.22).



Effect of dwarf rootstock (Taliparamba-1) on growth habit of variety VRI-3

2.8 Effect of paclobutrazol on growth and yield of cashew

The grafts of Ullal-3, field planted during 2009 at a spacing of 3m x 3m, were subjected to shape pruning to keep the main stem free of branches upto a height of 75 cm. Paclobutrazol was applied as a soil drenching treatment at a concentration of 0.5, 1.0 and 1.5 g a.i. per plant. Observations on growth parameters were recorded before and after the imposition of paclobutrazol treatment. Paclobutrazol application reduced the growth of plants with respect to parameters like plant height, canopy spread and internodal length. The girth of the stem and number of flushes increased with the application of paclobutrazol treatment (Table 2.23).



Growth habit of VRI-3 as seen on a vigorous root stock (V-4)

Table 2.22: Growth parameters 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)
Ullal-3/V-4	3.00	9.92	23.03	21.58	3.14
VRI-3/V-4	2.98	11.50	22.83	19.91	2.53
NRCC Selection-2/V-4	2.60	12.75	23.00	20.94	3.00
V-4/V-4	3.00	12.58	24.28	22.19	2.81
Ullal-3/ Brazil dwarf	3.14	12.63	26.83	23.82	3.33
VRI-3/ Brazil dwarf	3.40	13.72	26.45	23.15	3.30
NRCC Selection-2/ Brazil dwarf	2.55	12.71	21.59	18.82	2.65
V-4/ Brazil dwarf	2.52	9.92	21.45	19.31	2.34
Ullal-3/ Taliparamba-1	3.00	10.49	23.72	21.00	2.66
VRI-3/ Taliparamba-1	2.34	12.05	20.18	17.77	2.62
NRCC Selection-2/ Taliparamba-1	1.86	11.90	17.17	13.00	1.83
V-4/ Taliparamba-1	2.71	10.83	18.33	15.17	2.06
CD at 5%	1.08	2.41	NS	NS	NS

Table 2.23: Growth parameters of cashew as influenced by paclobutrazol (PBZ) application

Period of observation	Plant height (cm)	Stem girth (cm)	Canopy spread (cm)		Inter nodal length (cm)	No. of flushes
			E-W	N-S		
Pre-application	109-131	11-13	72-97	68-103	3.14-4.71	12-19
Post-application	125-300	11-24	75-250	98-260	0.4-3.0	20-265
	($T_1 - T_0$)	($T_{11} - T_0$)	($T_7 - T_0$)	($T_1 - T_0$)	($T_1 - T_0$)	($T_{11} - T_0$)

T_0 : Control; T_1 : 0.5 g a.i. PBZ; T_7 : 1.0 g a.i. PBZ; T_{11} : 1.5 g a.i. PBZ

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3. CROP PROTECTION

3.1 Cashew Stem and Root Borers (CSRB)

Under the trials on standardizing semi-synthetic diet (SSD) for laboratory rearing of cashew stem and root borers (CSRB), though the grubs of CSRB could complete the life cycle on SSD, only a small percentage of pre-pupae could form normal cocoon and cocoon formation was incomplete in majority of pre-pupae, which led to high level of mortality. Inclusion of calcium salts at different concentrations to enhance normal cocoon formation is being evaluated.

3.1.1 Evaluation of various calcium salts in SSD to enhance normal cocoon formation by CSRB grubs

In order to enhance cocoon formation by CSRB grubs, three different salts of calcium viz., calcium chloride, calcium carbonate and calcium sulphate (all at 0.5%) were added during the preparation of SSD. The SSD comprised of bergalgram flour, paddy straw powder, saw dust, sucrose and mineral salts along with an anti-fungal antibiotic viz., griseofulvin. The above constituents of SSD were boiled and stabilized in agar agar media and homogenised when still hot and poured into rearing bottles (500 ml glass bottles). Young grubs of CSRB which were approximately 15 days old, were released into the fresh composition of SSD in

such rearing bottles. It was noticed that the grubs could feed and grow normally on this SSD.

3.1.2 Evaluating LT_{50} of various Entomopathogenic Nematodes (EPN) species obtained from NBRI

Three different species of EPN obtained from National Bureau of Agriculturally Important Insects (NBRI), Bengaluru viz., *Steinernema bicolorata indica*, *Heterorhabditis indica* and *Steinernema abbasi* have been tested for their virulence on CSRB grubs of *Plocaederus* spp. and *Batocera rufomaculata*. The uniform aged grubs of both these species were used for the evaluation of LT_{50} . The infective juveniles (IJs) of these EPN species were topically applied as aqueous solution at a concentration of 1000 IJs / grub. Later the grubs were placed in petriplates for emergence of next generation of EPN IJs.

Most of the grubs stopped feeding within the next two days after topical application of EPN and became moribund within 4-5 days. The LT_{50} for these species was calculated based on the number of treated CSRB grubs dying with that specific time period. It was observed that *Steinernema bicolorata indica* was most virulent to *Plocaederus* spp. while *Heterorhabditis indica* was most virulent to *Batocera rufomaculata* (Table 3.1).

Table 3.1: LT_{50} for different species of EPN

Species of CSRB	Species of EPN	LT_{50} (in days)
<i>Plocaederus</i> spp.	<i>Steinernema bicolorata indica</i>	10.25
	<i>Heterorhabditis indica</i>	16.00
	<i>Steinernema abbasi</i>	17.50
<i>Batocera rufomaculata</i>	<i>Steinernema bicolorata indica</i>	16.38
	<i>Heterorhabditis indica</i>	7.13
	<i>Steinernema abbasi</i>	11.33

3.1.3 Field collection of volatiles from host plant sources

Field collection of volatiles from the cut end of healthy cashew trees was undertaken by trapping the emerging volatiles into n-hexane. A polythene tubing was wrapped around the cut end of a secondary branch. This was in turn connected to a vacuum pump wherein the volatiles were bubbled through n-hexane in a flask kept in a ice-bath. The ice cubes were replenished as and when needed.

The set up was operated for 12 h and n-hexane was collected and stored in a freezer for further analysis.

3.2 Studies on insect fauna associated with stored cashewnuts / kernels

3.2.1 Evaluation of repellants against *Ephestia cautella* infesting stored cashew kernels

Occurrence of *Ephestia cautella* as a major pest of stored kernels was confirmed during the earlier surveys. Different food grade insect repellents were evaluated for their ability in inducing the mortality of larvae of this pest on stored cashew kernels. The dosage of test repellants viz., methoxy benzaldehyde and ortho-guaiacol (vanillin) was determined by treating cashew kernels by placing filter discs impregnated with 0.5 to 1.5 per cent of the test material at the base of the containers and at the centre of the container. Larvae of *Ephestia cautella* (50 nos) obtained from the laboratory culture were released into the treated cashew kernels and mortality of the larvae released was recorded at 24 h after treatment. The odour staining of the treated kernels was also observed 24 h after treatment.

It was noticed that all released larvae died within 6 h after release and the treated kernels had high degree of odour staining of treated kernels due to the treatment even at the lowest concentration. Hence, the dosage of the food grade repellents was further reduced and is being evaluated at 0.025 to 0.50 per cent for the two test compounds. Trials have been initiated for evaluation of efficacy of lemongrass oil and clove oil in inducing mortality of larvae of *E. cautella*.

3.3 Determination of levels of different insecticides used in the management of pests of cashew in apples

The cashew apple samples were collected at

regular intervals after treatment (on the same day 1, 3, 7, 14, 21 and 28 days) with λ -cyhalothrin (0.003%). The samples were shade dried and got analyzed for the presence of residues of insecticides at Cashew Export Promotion Council of India (CEPCI) Quality Control Laboratory, Kollam. The residues level fell below the Maximum Residue Limit of 0.2 ppm within 15 days of treatment.

The cashew apple samples were collected at regular intervals after treatment (on the same day 1, 3, 7, 14, 21 and 28 days) with carbaryl (0.1%). The samples were shade dried and got analyzed for the presence of residues of insecticides at CEPCI Quality Control Laboratory, Kollam. The residues level fell below the Maximum Residue Limit of 0.5 ppm within 15 days of treatment.

3.4 Tea Mosquito Bug (TMB)

3.4.1 Biosystematics of TMB

For studies on biosystematics of tea mosquito bug (TMB) samples of TMB were collected from different parts of country where cashew is grown. The DNA from these samples was extracted using C-TAB method. PCR amplification of samples was done using mitochondrial cytochrome oxidase I gene (LCO/HCO). The amplified DNA was cut from the gel and elution was conducted. After elution, ligation was done for the eluted products. The transformation was done for the ligated product. During transformation the blue and white colonies were clearly visible. After the successful completion of transformation the plasmid DNA was extracted from the *E. coli* culture. Fermentas kit was used for plasmid extraction. The plasmid purity was visible in electrophoresis. DNA Barcoding was done by DNA sequence analysis of Mitochondrial DNA Cytochrome C Oxidase I gene (mtCOI). The mtCOI sequences for *Helopeltis* spp. from different geographical areas and host plants obtained in this study were aligned using the multiple alignment programme BioEdit v.7.0.

All sequence data obtained in the present study were deposited in the NCBI (National Centre for Biotechnology Information, National Library of Medicine, Building 38A, Bethesda, MD 20894, USA). The samples deposited are: *Helopeltis astonii* - cashew, Purtur (HM142602.1); *Helopeltis astonii* - cashew, Maçakathara (HM142604.1); *Helopeltis*

Helopeltis antonii - cashew, Paria (TM142605.1); *Helopeltis antonii* - cashew, Vengurla (M142607.1), *Helopeltis antonii* - cashew, Vengurla Organic farm (M142608.1); *Helopeltis antonii* - neem, Chintamani (TM142611.1); *Pachypeltis maesorum* - cashew, Puttur (M142612.1); *Helopeltis theivora* - *Acedypha hispida*, Payyanur (M142613.1); *Helopeltis antonii* - cashew, Padre (M990966.1), *Helopeltis theivora* - cashew, Puttur (M990968.1), *Helopeltis antonii* - cashew, Pilicode (TM142603.2), *Helopeltis antonii* - guava, Bangalore (M142610.20); and *Helopeltis antonii* - cocoa, Puttur (TM990967.2). The deposition of data for *Helopeltis* spp. of India at NCBI has been done for the first time.

3.4.2 Reaction of *H. antonii* in released and promising varieties of cashew

The varieties / high yielding accessions namely, Ullal-3, Ullal-2, Ullal-1, NRCC Selection-2, Bhaskara, VTH-304, VTH-174, VRI-3, Vengurla-1, Vengurla-3, Vengurla-4, Dhana, Kanaka, Priyanka, Madakkathara-2, K-22-1, NRCC Selection-1, Madakkathara-1, H-32-4, Ullal-4, Vengurla-7 and NRC-493 were observed for the incidence of tea mosquito bug. The damage due to the infestation of

pest was recorded on 0-4 scale (Grade 0 = no damage, 1 = 1-3 necrotic lesions, 2 = 4-6 coalescing lesions, 3 = > 6 coalescing lesions and 4 = complete drying) during flushing/flowering/fruitlet periods (Fig. 3.1).

The incidence of TMB was lower in Dhana with a mean damage score of 0.18. This was followed by Madakkathara-2 (0.21) and Ullal-1 (0.24). The incidence was higher in NRCC Selection-2 (0.41) and Vengurla-1 (0.42).

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

3.4.3.1 Foliar spray of major nutrients

The nutrient sprays namely : 1. urea (3%), 2. H_2PO_4 (0.5%), 3. K_2SO_4 (1%), 4. urea 3% + H_2PO_4 (0.5%), 5. urea 3% + K_2SO_4 (1%), 6. H_2PO_4 (0.5%) + K_2SO_4 (1%), 7. urea (3%) + H_2PO_4 (0.5%) - K_2SO_4 (1%) and 8. control were given thrice at flushing, flowering and fruitlet stages. The damage due to the infestation of pest was recorded on 0-4 scale at weekly intervals after first spray till completion of the harvesting. There was no significant difference in the damage rating in different treatments (Fig. 3.2).

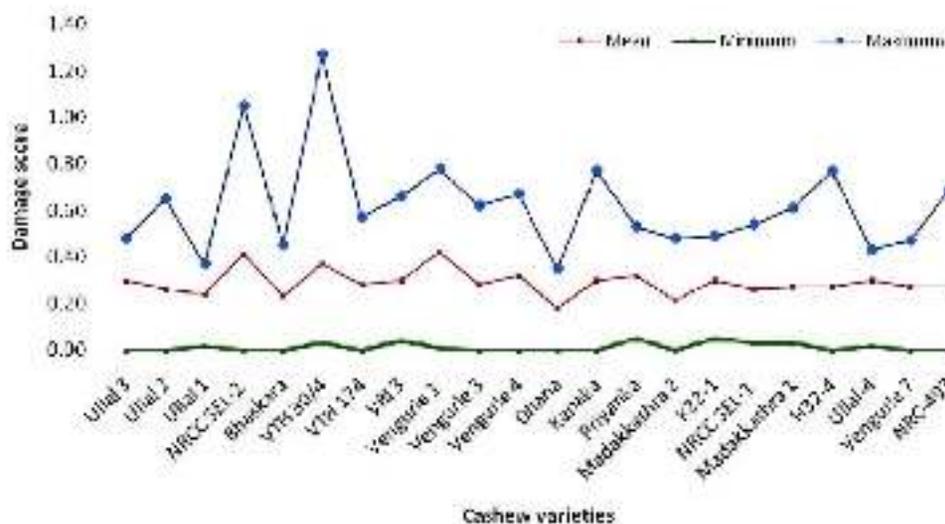


Fig.3.1: Reaction of released varieties to Tea Mosquito Bug

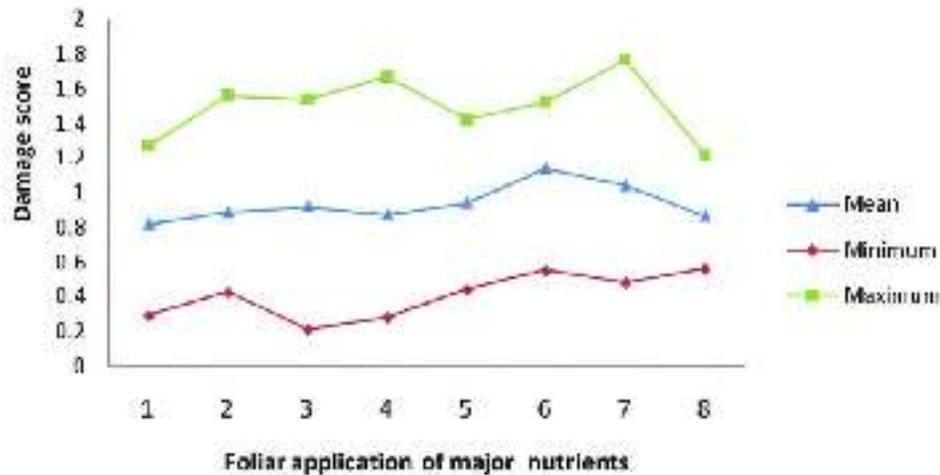


Fig. 3.2: Reaction of cashew variety NRCC Selection-2 with foliar application of major nutrients to Tea Mosquito Bug

3.4.3.2 Foliar spray of secondary and micronutrients

Foliar spray of secondary and micronutrients viz., 1. $ZnSO_4$ (0.5%), 2. Solubor (0.1%), 3. $MgSO_4$ (0.5%), 4. $ZnSO_4$ (0.5%) + Solubor (0.1%), 5. $ZrSO_4$ (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%) and 8. Control were given thrice at flushing, flowering and fruiting stages. The damage due to the infestation of pest was recorded on 0-4 scale at weekly intervals after first spray till completion of the harvesting. The incidence of TMB was lower in Solubor (0.1%) sprayed plots with a mean damage score of 0.84 with a range of 0.46-1.44. In untreated control the incidence of TMB was higher with a maximum of 2.92 (Fig. 3.3).

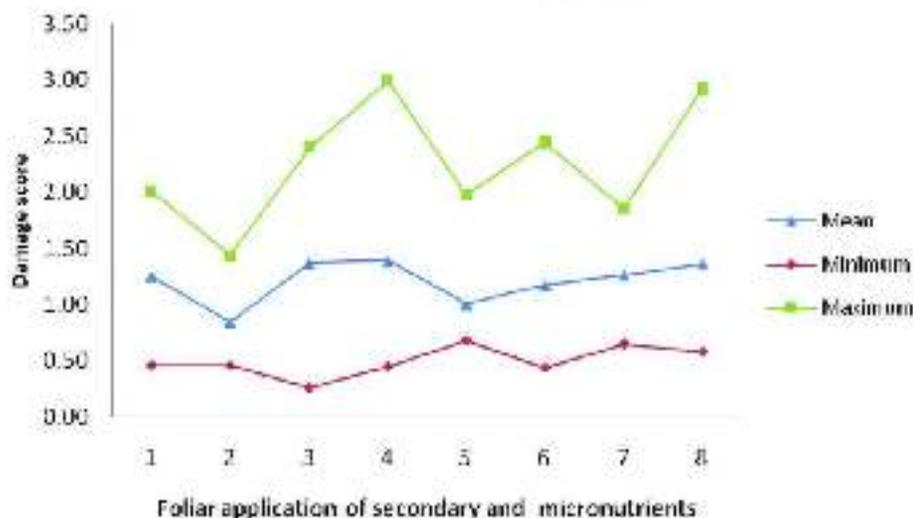


Fig. 3.3: Reaction of NRCC Selection-2 cashew variety with foliar application of secondary and micronutrients to Tea Mosquito Bug

3.5 Biodiversity of arthropod fauna in cashew eco-system

3.5.1 Documentation of insect pests, natural enemies and other arthropod species associated with cashew at DCR, Puttur

Co-existence of four species of tea mosquito bug viz., *Helopeltis antonii*, *H. bradyi*, *H. theivoca* and *Pachypeltis maesaranum* was observed during October 2010 to February 2011 in the experimental plots of DCR, Puttur (Table 3.2). Among these, *Helopeltis antonii* and *H. bradyi* were the dominant species. Both the species put together accounted for > 50 per cent of the TMB population during all the months of observation. The damage due to tea mosquito bug was > 50 per cent in few instances during this period.

Table 3.2: Species composition of tea mosquito bug during the period of peak activity

Month	<i>Helopeltis antonii</i>	<i>Helopeltis bradyi</i>	<i>Helopeltis theivora</i>	<i>Pachypeltis maesarum</i>	Total
Oct 2010	55 (66.27)	4 (4.81)	8 (9.64)	16 (19.28)	83
Nov 2010	97 (53.00)	34 (18.58)	24 (13.11)	28 (15.30)	183
Dec 2010	49 (37.98)	28 (21.71)	23 (17.83)	29 (22.48)	129
Jan 2011	101 (43.53)	77 (33.19)	26 (11.21)	28 (12.07)	232
Feb 2011	13 (50.00)	9 (34.62)	1 (3.85)	3 (11.54)	26

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

TMB rearing was done throughout the year by using tender shoots of cashew. There was not much variation in the life cycle of the insect during different months. The sex ratio was worked out during different months (Table 3.3) which revealed that activity of male was more in most part of the year. During March and April months, activity of adult female bug was more. In the month of February,

activity of both male and female bug was uniform. This period coincided with flowering and fruiting in most of the varieties of cashew.

The other insect pests recorded during this season are furnished in Table 3.4. Activity of leaf miner was noticed throughout the year, while, other pests were active during flushing/flowering/fruiting periods.

Table 3.3: Emergence of TMB during different months

Month	Number of male adults emerged	Number of female adults emerged	Sex ratio (M:F)
Apr 2010	11	16	0.69
May 2010	38	28	1.35
Jun 2010	32	26	1.23
Jul 2010	51	42	1.21
Aug 2010	26	23	1.13
Sep 2010	32	29	1.10
Oct 2010	68	53	1.28
Nov 2010	72	59	1.22
Dec 2010	53	48	1.10
Jan 2011	40	32	1.25
Feb 2011	32	31	1.03
Mar 2011	29	33	0.88

Table 3.4: Insects pests other than TMB recorded during 2010-11

Name of the pest	Period of activity
Leaf miner : <i>Conopomorpha (= Acrocercops) syngrella</i> M.	Throughout the year
Leaf and blossom webber : <i>Lamida (= Mucalla) monoculalis</i> Wlk.	November 2010 - February 2011
<i>Monolepta longitarvus</i> Jal.	June - August 2010
<i>Hypotima (= Chelaria) koligramma</i> M.	
Thrips : <i>Rhynchothrips roenalis</i> G.	
<i>Scirtothrips dorsalis</i> TE	December 2010 - March 2011
<i>Thylocapilla paucisema</i> M.	March 2011

The activity of spiders was monitored in cashew and it was noticed throughout the year. A total of 24 species of spiders was recorded

(Table 3.5) during this year, They were feeding on tea mosquito bug and other insects occurring on cashew.

Table 3.5: Spiders associated with cashew

Name of the species	Period of activity
<i>Araneus mitificus</i>	January 2011
<i>Argiope</i> sp	November 2010
<i>Cassiracantha geminata</i>	March 2011
<i>Neoscona</i> sp	January 2011
<i>Oxyopes skweta</i>	November 2010 - March 2011
<i>Pisaura gitae</i>	November 2010 - January 2011
<i>Epeus indicus</i>	November 2010 - March 2011
<i>Epevella aurantiaca</i>	December 2010
<i>Hylla</i> sp	February 2011
<i>Myrmarochne platyleoides</i>	March 2011
<i>Phintella</i> sp	December 2010 - March 2011
<i>Plexippus paykalli</i>	November 2010
<i>Siler semiglaucus</i>	March 2011
<i>Tetranomia dandiluae</i>	October 2010 - March 2011
<i>Thiania</i> sp	February 2011
<i>Olios nilleti</i>	January 2011
<i>Tetragnatha</i> sp	November 2010
<i>Chrysa argyroformis</i>	January 2011
<i>Comaricus formosus</i>	January 2011
<i>Thomisus</i> sp	December 2010
<i>Parawisia</i> sp	December 2010
<i>Oxytate virens</i>	March 2011
<i>Asemonea tenuipes</i>	March 2011
<i>Oxyopes rufandae</i>	November 2010 - March 2011



Oxyopes shweta



Oxyopes sunandae



Siler semiglaucus



Epeus indicus

Some of the commonly occurring spiders on cashew

The egg parasitoids *Telenomus* and *Chaetostrihia* was recorded in the egg samples collected both from DCR farm at Kemrinaje and DCR Experimental Station at Shantigodu. The activity of *Telenomus* species was noticed in the samples collected from Belgaum, Karnataka and Goa. This is the first record of egg parasitoid on TMB from these cashew growing regions.

3.5.2 Documentation of insect pests, natural enemies and other arthropod species associated with cashew in major cashew growing areas of the country

The incidence of pests was also recorded in other cashew growing areas of the country and the details are given in Table 3.16.

3.6 Evaluation of causes for black spot formation in cashew kernels

Occurrence of black spots on processed kernels is one of the main set back faced by cashew processors which leads to severe monetary loss as damaged kernels are re-assigned to lower grades. In

order to establish any relationship between insect infestation and level of black spot occurrence field trial was initiated wherein, the emerging panicles were marked suitably and some of them were randomly caged during different months, using a fine mesh cotton cage to avoid incidence and damage by any insect pests. The other marked panicles were left uncaged. The nut samples obtained from uncaged panicles were processed and it was noticed that the intensity of black spot occurrence in uncaged panicles ranged between 2.12 to 7.22 per cent by weight. The damage on cashew kernels obtained from caged panicles is being estimated.

3.7 Evaluation of synthetic fungicides against flower drying disease of cashew

Synthetic fungicides viz., mancozeb, copper oxy-chloride, carbendazim and propiconazole were sprayed on to the cashew trees of variety NRCC Selection-2 in which the problem of flower drying is very serious. The unopened flowers due to the disease were estimated in the sprayed trees. In the trees sprayed with mancozeb the incidence of disease was lower (9.3%) compared to untreated control (20.2%).

Table 3.6: Incidence of pests of cashew in other cashew growing areas

State	Name of the pest	Period of activity
Northber: Karnataka (Belgaum)	Leaf miner : <i>Conopomorpha (= Acrocercops) syngamma</i> M.	Dec 2010
	Semi-looper : <i>Gonaspila flavofuscalata</i>	Nov - Dec 2010
	Tea mosquito bug : <i>Helopeltis antonii</i> Sig.	Nov - Dec 2010
Orissa (Bhubaneswar)	<i>Hypotima (= Chelaria) haligramma</i> M.	Feb 2011
	Leaf miner : <i>Conopomorpha (= Acrocercops) syngamma</i> M.	Feb 2011
Gujarat (Valsad and Dang districts)	Leaf and blossom webber	Nov 2010 - Feb 2011
	Tea mosquito bug : <i>Helopeltis antonii</i> Sig.	Nov 2010 - Feb 2011
West Bengal (Jhargham)	Leaf and blossom webber <i>Loxida (= Macalla) nuncosalis</i> Wlk.	Nov 2010 - Feb 2011
	Tea mosquito bug : <i>Helopeltis antonii</i> Sig.	Nov 2010 - Feb 2011
Goa	Tea mosquito bug : <i>Helopeltis antonii</i> Sig.	Feb 2011
	Leaf miner : <i>Conopomorpha (= Acrocercops) syngamma</i> M.	Feb 2011



4. POST-HARVEST TECHNOLOGY

4.1 Design and development of dryer for raw cashewnuts

Drying characteristics of in-shell cashewnut under convective air drying was studied at laboratory level. Freshly harvested in-shell cashewnuts were manually graded into small, medium and large size nuts and exposed to hot air maintained at temperature of 40°C, 50°C and 60°C. Small, medium and large sized nuts samples were dried to less than 8.00 per cent moisture from 11.64 per cent, 16.69 per cent and 17.69 per cent respectively. Rapid diffusion of moisture observed in the beginning *i.e.*, first 30 min. of drying and slowed towards end of drying. Moisture loss increased at higher drying temperature *i.e.*, 60°C than at lower air temperature of 40°C. Moreover, 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.

Variation in the moisture movement related to the composition of in shell cashewnut which has three different layers *viz.*, shell, tests and kernel could be the limiting factor for lowering moisture loss during drying. The drying rate increased from 2.54×10^{-4} to 7.38×10^{-4} , 1.92×10^{-4} to 6.23×10^{-4} and 1.55×10^{-4} to 3.96×10^{-4} g of water/min/g of the dry matter for large, medium and small sized nuts, respectively with the increase in air temperature from 40°C to 60°C. The drying of in-shell cashewnut followed falling rate period throughout drying process.

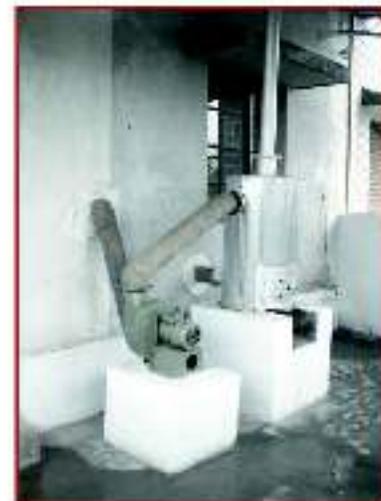
Dryer for raw cashewnuts with dual mode (Electrical and biofuel power operated) is fabricated,

installed and commissioned at DCR, Puttur. Basic trials were conducted to confirm hot air circulation inside drying chamber; distribution of hot air inside (top, middle and bottom tray positions), supply of hot air from heat generation unit and time required for stabilization of hot air. 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°C 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 results showed that drying air temperature and size of the nut significantly influenced the total drying time.

Trials were conducted with water soaked nuts of various sizes *viz.*, small (<20.0 mm), medium (20.1-24.0 mm) and large (>24.0 mm) placed at different locations maintaining air temperatures of dryer at 40°C, 50°C and 60°C. Initial moisture content of the soaked raw cashewnuts were found to be in the range of 15.08 to 17.93 per cent (d.b). Surface colour of the kernel extracted from raw cashewnuts retained its original colour after exposed to different temperatures. Total energy requirement to reduce the moisture content to safer level of artificially soaked raw cashewnuts were determined for different air temperatures for both cases *viz.*, electrical and bio-fuel (cashew shell cake). Drying of raw cashewnuts followed falling rate of drying and required 2.5 to 3.0 h to reduce the moisture content to safer level of 8 per cent d.b irrespective of fuel used for generation of hot air.



Front view of dual mode raw cashewnut dryer



Rear view of dual mode raw cashewnut dryer

4.2 Studies on alternate energy utilization of cashew shell cake (CSC)

The CSC was gasified in updraft gasifier and consistent gasification was observed. The biomass consumption, specific gasification rate, relation of variation in flame temperature with air inflow, trend of biomass consumption with air inflow was computed. The gasifier was tested for more than 70 h and rate of biomass consumption was worked out to be 8 to 10 kg hr⁻¹. The flame temperature varied from 387°C to 718°C in different experiments with average mean value of 587°C. The tar generation with CSC was observed to be high and deposited in the gas conduit with the progressive run of the gasifier. Specific gasification rate was computed as 116 kg hr⁻¹ m⁻². Protocol for operating gasifier with CSC was developed.

Preliminary trials on briquetting cashew shell cake using ram and piston type densification unit at CIAE, Bhopal was conducted. It was found that briquettes could be formed using cashew shell cake in pulverized form along with highly cellulosic plant materials especially stalk of the plants. Accounting major thermal operations in the line of cashewnut processing *viz.*, raw cashewnut conditioning (steam boiling) and unpeeled kernel drying, total thermal energy requirement was worked out to be 4.13 kw for installed capacity up to 1000 TPA.

4.3 Development of compact type drum roasting machine for raw cashewnuts

Preliminary trials were conducted to assess the performance of compact type drum roasting machine for raw cashewnuts at CIAE, Bhopal. Various problems encountered during trials *viz.*, chocking of nuts at the exit point of feed hopper to roasting drum, diverting smoke towards chimney, inclusion of bucket elevator for maintaining feed rate etc., were attempted. Accounting the above mentioned problems, drum roasting machine was modified and tested for its performance at CIAE, Bhopal. This tested drum roasting machine is shifted to DCR, Puttur for installation and performance evaluation.

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

4.4.1 Heterogeneity in physical characteristics of raw cashewnuts in relation to quality standards

Various indigenous varieties *viz.*, Ullal-1,

Ullal-2, Ullal-3, Ullal-4, Vengurla-1, Vengurla-3, Vengurla-4, Vengurla-7, NRCC Selection-1, NRCC Selection-2, Bhaskara, Dhana, Kanaka, Priyanka, Maddakkattara-2, VRI-3 and imported origin nuts *viz.*, CDJKL (Tanzania), Guinea Bissau, Gambia, Ivory Coast, Indonesia and Tanzania were used to determine physical parameters such as number of nuts/kg, moisture content, spatial dimensions of raw cashewnut and its kernel, shelling percentage and spoiled nuts percentage. Heterogeneity in physical characteristics of raw cashewnuts was confirmed and data thus collected transferred to Kerala State Cashew Development Corporation - KSCDC (Consortium Partner) for validation and developing empirical relationship. In consultation with cashew processors, traders and farming community various standards being followed to assess quality of raw cashewnuts were identified. After grouping the quality parameters, its influence on the price structure is being worked out.

4.4.2 Development of rotary grader for raw cashewnuts

A motorized concentric drum type rotary sieve grader for raw cashewnuts was developed and installed. This unit consists of feed control mechanism (bucket elevator), feed hopper, concentric rotary sieve drums and a drive mechanism. Feed hopper is constructed with galvanized iron and hopper bottom connects inlet of inclined rotary sieve drum. Blinding of nuts inside the sieve wholes can be prevented by rotary motion (due to gravitational fall).



Concentric drum type rotary sieve grader

Hopper bottom would facilitate in collecting the graded nuts just below each concentric rotary drum. A 2.0 hp and 0.5 hp electrically powered single phase DC motors are coupled to sieve drums and feed controller respectively. The effective width of the nut was used as criteria to size grade the raw cashewnuts and circular *c/s* sieves of size of 20 mm ϕ , 22 mm ϕ and 24 mm ϕ were selected. Considering the strength of mild steel perforated sheet with zig zag sieve holes was selected for fabrication of rotary sieve cylinders. Optimization of processing parameters for higher grading efficiency is under progress.

4.4.3 Performance of steam assisted unpeeled cashew kernel dryer

The performance evaluation of steam assisted cross flow dryer was investigated for unpeeled cashew kernels. All the drying experiments were performed using steam assisted cross flow dryer available at M/S Kalbhavi Cashews, Baikampady Industrial Area, Mangalore, Karnataka, India. The steam assisted dryer is a forced convective type with blowers on either side providing total air circulation on double passing principle. This dryer has the capacity of about 800 kg of unpeeled cashew kernels per batch and consists of mainly three components viz., steam generation unit, drying chamber with heat exchangers, blowers and electronic control unit.

The dryer is of double walled design with inner chamber made up of mild steel and finished with heat resistant aluminum paint. Annular space between the walls is filled with glass wool to provide thermal insulation. Two steam heat exchangers *i.e.*, radiators and fins assembly having capacity up to 7 kg cm^2 steam pressure are fitted diagonally opposite to each other. Externally generated steam is passed into the heat exchangers to transfer heat for drying process inside the dryer. Inlet and outlet pipes are provided at appropriate locations to ensure supply of ambient air and removal of moist air from the dryer. Electric control panel consists of temperature indicator, on/off switches, indicator for fans and other safety features is also provided. Initial moisture content of the unpeeled cashew kernels was found out to be 7.0 per cent (d.b.) and it was exposed to hot air maintained at $80 \pm 2^\circ\text{C}$ for a period of 9 h. Performance of the steam assisted cross flow dryer was evaluated in terms of rate of drying and peeling efficiency.

Initial moisture content of samples *i.e.*, 7.0 per cent d.b. placed in trolleys T_1 and T_2 at different

positions on front side of the dryer *viz.*, top (P_1), middle (P_2) and bottom (P_3) trays of dryer was reduced to 0.82, 0.36, 0.04 per cent and 0.07, 0.54, 0.61 per cent respectively after 9 h of drying. But the final moisture content of samples placed in adjacent trolleys T_3 and T_4 of front side of the dryer as shown in Fig. 4.1 was found to be 0.46, 0.18, 0.11 and 0.43, 0.46, 0.18 per cent at tray positions P_1 , P_2 and P_3 , respectively. Similarly, reduction in the moisture content was observed to be 0.07, 0.04, 0.29 and 0.29, 0.21, 0.25 per cent for the samples placed at positions P_1 , P_2 and P_3 in trolleys T_3 and T_4 at rear side of dryer, respectively. Moisture content of the samples placed in adjacent trolleys T_5 and T_6 located on the rear side of dryer decreased to 0.46, 0.25, 0.54 and 0.61, 0.25, 0.18 per cent at positions P_1 , P_2 and P_3 respectively from an initial moisture content of 7.0 per cent.

Final moisture content of the samples placed in trolleys on front side *viz.*, T_1 , T_2 , T_3 and T_4 ranged from 0.04 to 0.82 per cent (d.b.) and on the rear side *viz.*, T_5 , T_6 , T_7 and T_8 ranged between 0.04 and 0.61 per cent (d.b.) of dryer was on par with each other. This indicates that in spite of differential rate of drying recorded up to 6 h, moisture loss from samples reached more or less uniform during 9th h of drying irrespective of its position inside the dryer. In general, the moisture content of unpeeled cashew kernels was reduced to less than 3.0 per cent in the first 3 h of drying and below 1.0 per cent after 9 h of drying. Movement of humid air towards outlet provided at the top of the dryer and circulation of hot air from bottom to top were the due reasons for the variation in the moisture from the unpeeled cashew kernels inside the dryer.

The effect of drying time on peeling efficiency of unpeeled cashew kernel placed at different position of trolleys in a steam assisted cross flow dryer, it was evident that peeling efficiency of unpeeled cashew kernels increased with drying time *i.e.*, 1.95 to 88.43 per cent. It varied from 1.95 to 27.49 per cent and 30.29 to 79.38 per cent for unpeeled cashew kernels dried for 3 h and 6 h respectively placed in various trays of different trolleys. But the values ranged from 72.22 to 88.43 per cent after 9 h of drying for the unpeeled cashew kernels kept in different location inside the dryer. Peeling efficiency of samples placed in trolleys 1, T_3 , T_1 and T_4 on front side of dryer was found to be 84.95 (T_1P_1), 88.24 (T_2P_2), 85.04 (T_3P_3), and 81.44 (T_4P_3) per cent, respectively after 9 h of

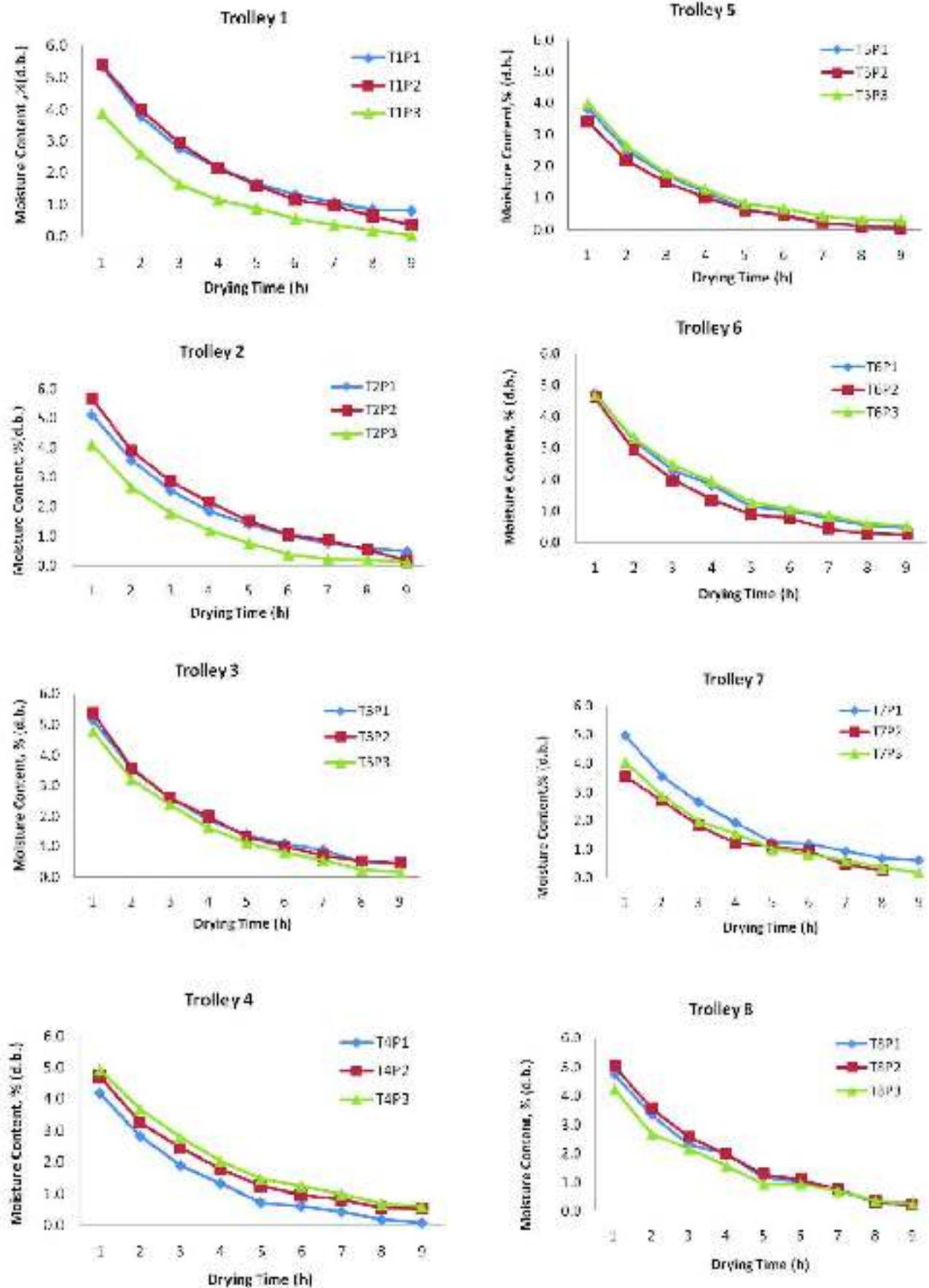


Fig. 4.1. Variation in the moisture content (d.b.) of unpeeled cashew kernels w.r.t. drying period inside steam assisted cross flow dryer

drying which was higher than unpeeled kernels dried for 6 and 3 h. Practically, moisture content of unpeeled cashew kernels reduced to 1.0 per cent after 9 h of drying ensured manual peeling process better and kernels dried for 3 or 6 h period could not attain the required moisture level to ease manual peeling.

The total electrical, thermal and manpower utilized for drying unpeeled cashew kernels in steam assisted cross flow dryer having capacity of 800 kg batch¹ was 97.23, 3684.43 and 0.23 Mega Joule (MJ), respectively. But the brick constructed dryer (Berma) utilized 106.92, 4421.32 and 0.23 MJ of electrical, thermal and manpower for the drying operation, respectively. Overall, the total energy utilized for drying 800 kg of unpeeled cashew kernels was found to be minimum *i.e.*, 3781.86 MJ for steam assisted cross flow dryer than brick constructed dryer *i.e.*, 4528.47 MJ. Better heat utilization efficiency is the due reason for minimal energy requirement for drying process in the case of steam assisted cross flow dryer than in brick constructed dryer. Further, attaining desired temperature within a short period of time and automatic control over air temperature inside are the principal advantages over existing brick constructed dryer.



Steam assisted cashew kernel dryer

4.4.5 Comparative performance of steam assisted and brick constructed dryer for unpeeled cashew kernels

Performance of two different drying systems *viz.*, brick constructed dryer (Berma) which is being followed in majority of the cashewnut processing units and steam assisted cashew kernel dryer which is an advanced technique and recent introduction in the cashewnut processing industries were worked out.

During steam assisted drying process, about 37 per cent of thermal energy per kg could be saved over brick constructed dryer. Peeled whole kernel recovery ranged from 68.81 to 88.71 per cent for steam assisted dryer after drying for 8 h whereas it ranged from 58.93 to 81.25 per cent for brick constructed dryer after 23 h respectively. Air temperature is automatically controlled in steam assisted dryer whereas it requires constant supervision and manually controlled in brick construction.

4.4.6 Energy budgeting of cashewnut processing industries in India

Data pertaining to energy utilization in cashewnut processing units located in Karnataka, Kerala, Andhra Pradesh, Goa and Maharashtra at different stages of processing was collected using pretested questionnaire. Energy budgeting of cashewnut processing industries in various regions indicated that, on an average total human, electrical and thermal energy utilized in drum roasting was found to be 21.71 MJ, 41.43 MJ and 1.76 MJ per kg of raw cashewnuts, respectively compared to 17.03 MJ, 17.03 MJ and 1.84 MJ per kg of raw cashewnuts in the case of steam boiling method. Irrespective of the mode of processing, total human energy required was found to be higher in shelling *i.e.*, in the range 2.30 to 103.50 MJ followed by peeling process which is in the range of 2.30 to 89.28 MJ 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 1.021 MJ per kg of raw cashewnuts. After the introduction of mechanized peeling machine and kernel grader especially in Karnataka state, electrical power consumption increased in the line of processing. As far as the thermal power is concerned, steam boiling and kernel drying operation in line utilizes thermal power and mostly derived from by-product of the cashew industry. Total thermal energy expended on cashewnut processing was found to be in the range of 0.46 MJ to 7.57 MJ per raw cashewnuts irrespective of mode of processing.

4.4.7 Comparative performance of mechanised cashew kernel peeling machine

Performance of various mechanized peeling machines available in India *viz.*, brush type, abrasion and pneumatic type, impact and shear type were assessed for its performance in terms of peeling capacity, peeling efficiency, cost, flour space and power requirement.



Brush type mechanized peeler

In case of brush type peeling machine, unpeeled cashew kernels after hot air drying were steam treated inside a cubical chamber for 6 to 9 min., depending on the origin of the raw cashewnuts. After steam treatment, moistened cashew kernels were dried in hot air dryer for 2 h maintained at air temperature of 75°C for 2 h. Peeling efficiency and whole kernel recovery were 65.28 and 56.34 per cent, respectively.



Abrasive and pneumatic type mechanized peeler

Abrasive and pneumatic type peeler consists of feed hopper, conveyor, peeling drum (2 nos. parallel to each other), compressor, unpeeled / peeled kernel and testa outlets. Dried unpeeled kernels were subjected to humidified environment to increase the moisture content. During peeling operation, unpeeled kernels were subjected to abrasion against inner drum surface due to centrifugal force. Rotational speed of the abrasive drum is prefixed by trial and error method. Control mechanisms were provided for feed rate and time of peeling inside the abrasive drum. Performance of the unit was worked out to be in terms of peeling efficiency (70.54%) and whole kernel recovery (59.30%).

Imported machine from Vietnam consists of feed hopper, bucket elevator, peeling drum (3 concentric drum), pneumatic peeling system and rotary kernel grader. Unpeeled pre treated cashew kernels were fed into the peeling drum, wherein kernels were subjected to impact and shear force by numerous spring loaded hook like structure mounted on central shaft. Afterwards, kernels with loose testa were passed into the pneumatic peeling system wherein high pressure air removed testa layer completely. Peeling efficiency and whole kernel recovery were assessed as 71.37 and 64.69 per cent, respectively.



Imported mechanized peeling machine

5. TRANSFER OF TECHNOLOGY

5.1 Establishment of demonstration plots

During the year, 16 demonstration plots were established in farmers' fields located in Puttur, Sulia and Banwal taluks of Dakshina Kannada district of Karnataka covering an area of 20 ha. These plots were established with financial support of NHM programme of DCCD, Kochi. Technical guidance on cashew varieties, high density planting and soil and water conservation techniques in cashew was provided to the farmers while laying out these demonstration plots. Regular visits were made to these demonstration plots by a team of Scientists. The demonstration plots established earlier were also monitored and technical advice was given whenever required.

5.2 Exhibition / Demonstration

This Directorate participated in several exhibitions / expos by putting up stalls on developments and achievements in cashew research. Posters, charts and live specimens were displayed with the extension literature. The visitors / dignitaries / farmers were given the information on the achievements, development and good cashew cultivation practices. This Directorate bagged the prize as one of the best stalls in exhibition organized at CPCRI, Kasaragod in the International Conference on Coconut Biodiversity for Prosperity during 25-28 October, 2010.

The details of participation of DCR, Puttur during the year:

- Exhibition organized by University of Horticultural Sciences at Bangalore Campus as part of "Swadesh Prem Jagrithi Sangosti 2010" - National Conference on Horticultural Biodiversity for Livelihood, Economic Development and Health Care (29-31 May, 2010).
- Exhibition organized by Department of Agriculture, Govt. of Karnataka at APMC, Puttur, in connection with Krishi Mahotsava

Programme of Govt. of Karnataka (23-26 June, 2010).

- Exhibition organized at IHR, Bangalore in connection with Horticulture Industry Meet as part of HIMU programme (11 November, 2010).
- Exhibition organized at CPCRI, Kasaragod as part of International Conference on Coconut Biodiversity for Prosperity (25-28 October, 2010).
- Exhibition organized at Trichirapalli as part of Global Conference on Meeting Challenges in Banana and Plantain for Emerging Biotic and Abiotic stresses (December 10-13, 2010).
- Exhibition "AGRIVISION" organized at NBTGR, Lucknow as part of Agricultural Science Congress held at Lucknow (10-12 February, 2011).
- Exhibition organized at CPCRI (RS), Modipuram as part of Udyan Mela at Modipuram (5-6 March, 2011).

5.3 Training programme

A training programme (Refresher Course) on Cashew Production Technology was organized during 19-21 January, 2011 for 14 participants from DHRUVA, Kaprada, an unit of BAIF, Pune in Gujarat and Plantation Corporation of Kerala (PCK), Kerala. The latest developments in Cashew Production Technology were explained to the trainees during the training programme.

5.4 Cashew day

Cashew day was organized on 1 March, 2011 in which more than 250 farmers participated. Farmers were given exposure visits to experimental plots of DCR, cashew museum and also to a farmer's plot to show the performance of different cashew varieties and the results of various cashew production technologies.



Field visit during cashew day

A group discussion was organized on the occasion in which the farmers and experts were given opportunity to talk on cashew related activities. There was a discussion on formation of cashew growers association led by the Chairman of Karnataka State Souharda Federal Co-operative Ltd. There was a question and answer hour in which farmers were given information sought on cashew and cashew related problems.

5.5 Advisory visits / Consultancy

The scientists were requested to offer technical advice / lectures on cashew production technology by various organizations. The requests were considered and scientist / team of scientists were deployed for the assignment as detailed below:

- A team of scientists visited the plots of tribal farmers in Gujarat (Dang, Navsari and Valsad districts) and Maharashtra (Nusik and Thane districts) and offered expert advice as part of consultancy to BAIF, Pune's units "DHRUVA" in Gujarat and "MITRA" in Maharashtra (19 - 24 December, 2010).
- A team of scientists participated in the Workshop cum Seminar on cashew organized at College of Agriculture, Indira Gandhi Krishi Vishwa Vidyalaya, Jagdalpur, Chattisgarh and delivered lectures on various aspects of cashew cultivation (4-5 January, 2011).
- A scientist participated in State Level Workshop on Cashew organized by ARS, Vridhachalam, Tamil Nadu and delivered a talk

on Training and Pruning in Cashew (24 February, 2011).

- Scientists participated in Cashew day programme of ZARS, Brahmavar (9 October, 2010) and ARS, Ulal (12 February, 2011) and delivered lectures on Cashew Production Technology.
- Scientists participated in a training programme on "Technology Dissemination" at KVK, Mangalore and delivered lectures on Production and Processing aspects of cashew (4 February, 2011).

5.6 Radio talks / TV programmes

During the year, interviews were recorded on varieties of cashew and pests of cashew, and broadcast by AIR, Mangalore.

A TV interview was recorded on varieties of cashew at ARS, Jagdalpur in Hindi language and was telecast on 8 January, 2011.

A series of recordings on various aspects of cashew cultivation was done during the month of March, 2011 by Daardarshan-1, Chandana (Kannada) TV channel (Telecast from the month of April, 2011 onwards).

5.7 Video film on DCR

A video film on DCR covering research developments and achievements of 10 minutes duration was produced for screening in Directors conference of ICAR and also to have information on DCR at ICAR Headquarters.

5.8 Evaluation of cashew expansion programme

Scientists 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 KCDC, Karnataka; GFDC, Goa and plantations raised by farmers under cashew expansion programme of National Horticulture Mission in Karnataka for inspection and evaluation.

5.9 Planting material generation and distribution

During the year, more than two lakh cashew grafts of different high yielding 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.

5.10 Cashew literature

During the year, technical bulletin on softwood grafting and nursery management in cashew was revised and got reprinted. The following pamphlets in Kamada language were revised and got reprinted.

- Cashew Production Technology - "Sudharitha Geru Besaya"
- Rejuvenation in Cashew - "Geru Maragala Punhaschetana"
- Training and Pruning in Cashew - "Geru Gidagala Savanuvike"
- High Density Planting in Cashew - "Ghana Sandra Besaya Padilathil"

5.11 Visitors

During the year, more than 20 batches of farmers and students and several other farmers visited the Directorate seeking information on cashew cultivation. Visitors were briefed about the activities of the Directorate, cashew cultivation practices and research achievements. They were also taken for exposure visit to cashew experimental plots and cashew nurseries and briefed about activities. Queries received through several letters / phone calls / e-mails from farmers seeking information on cashew / technical advice were replied.

5.12 Cashew germplasm database

Cashew germplasm data is voluminous and its management and retrieval by conventional methods is time consuming. Development of computational tools and organization of centralized database system, which can be shared and secured is of paramount importance. Cashew germplasm passport information (1149), accessions (255) and descriptors (68) database has been developed using Active Server Pages supported by a Java/VB Script.



**EDUCATION
TRAINING
GENERAL
MISCELLANEOUS
INFORMATION**

6. EDUCATION AND TRAINING

A training programme (Refresher Course) on Cashew Production Technology was organized during 19-21 January, 2011 for 14 participants from DHRUVA, an unit of BAIF, Pune in

Gujarat and Plantation Corporation of Kerala (PCK), Kerala. The latest developments in Cashew Production Technology were explained to the trainees during the training programme.

7. LINKAGES / COLLABORATION

Collaboration between DCR and other organizations

Name of the organization	Type of collaboration
Indian Institute of Horticultural Research, Bangalore	Bio-systematics of tea mosquito bug <i>Helopeltis cottonii</i> Signoret.
National Bureau of Agriculturally Important Insects (NBAIL), Bangalore	Identification of kairomones / pheromones of major pests of cashew.
University of Agricultural Sciences (UAS), GKVK Bangalore	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.
<ul style="list-style-type: none"> • SKDRDP, Dharmasthala • Manaje Vyavasaya Satkari Seva Society, Kantalashile • Nagaiika Seva Trst, Guruvayankode 	Maintenance of demonstration plots, trainings, distribution of planting materials and Annual Cashew Day.
Directorate of Cashewnut and Cocoa Development, Kochi	Farmers training programme, Annual Cashew Day and assistance for demonstration plots.
Cashew Export Promotion Council of India, Lab and Tech. Division, Kollam	<ul style="list-style-type: none"> • Insecticide residue analysis. • NAIP Project on "A value chain in cashew for Domestic and Export Market".
<ul style="list-style-type: none"> • 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.

8. AICRP - CASHEW CENTRES

Headquarters

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dircajures@rediffmail.com
dircajures@gmail.com
Website: <http://www.cashew.res.in>

AICRP - Cashew Centres

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- Regional Fruit Research Station (Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth), Vengurla -16 516, Sindhudurg District, Maharashtra.
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rsvri@gmail.com
- Agricultural Experimental Station (Navsari Agriculture University) Poria, Pardi taluk, Valsad District, Gujarat 396 145.
Telefax : 0260-2337227
E-mail : acsna@yahoo.co.in
- Zonal Research Station (Biswa Agricultural University) Datisai - 832 304, East Singhbhum District, Jharkhand.

Co-operating Centres

- KRC College of Horticulture (University of Horticultural Sciences) Arabhavi - 591 310, Gokak Taluk, Belgaum District, Karnataka.
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03651-222535 (Tura)
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9. PUBLICATIONS

9.1 Research publication

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Rejani, R. and Yadukumar, N. 2010. Soil and water conservation techniques in cashew grown along steep hill slopes. *Scientia Horticulturae*, 126:371-378. (Doi:10.1016/j.scientia.2010.07.032).

Rupa, T.R. and Bhat, M.G. 2010. Integrated nutrient management in cashew. *Indian Journal of Fertilisers* 6 (11): 62-66.

Shivayogappa, G., Dinakara Adiga, J., Prabhuling, G., Reddy, B.S., Nataraj, S.K., and Prashanth, S.J. 2011. In vitro conservation studies in Dahlia (*Dahlia variabilis* L.). *The Asian Journal of Horticulture*, 4(2): 470-472.

Shobha, D. and Thimmappaiah, 2011. Identification of RAPD markers linked to nut weight and plant stature in cashew. *Scientia Horticulturae* (in press).

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conductance and yield of cashew germplasm from three agroclimatic regions of South India. In: 19th Plantation Crops Symposium (PLACROSYM XIX), RRII, Kottayam, Kerala, during 7-10 December, 2010.

Balsubramanian, D. and Sandeep, T. N. 2010. Thin layer drying characteristics of in-shell cashewnuts in convective dryer. In: 19th Plantation Crops Symposium (PLACROSYM XIX), RRII, Kottayam, Kerala, during 7-10 December, 2010.

Bhat, M.G., Rupa T.R. and Rejani, R. 2010. Impact of climate change on cashew. In: 19th Plantation Crops Symposium (PLACROSYM XIX), RRII, Kottayam, Kerala, during 7-10 December, 2010.

Bhat, P.S. 2010. Scenario of cashew in Dakshina Kannada and Udupi districts. In: Krishi mela organized at Zonal Agricultural Research Station (ZARS), Brahmavar, Udupi district, Karnataka on 9 October, 2010.

Bhat, P.S. 2011. Strategies for the management of pests of cashew. In: Geru mela organized at Horticultural Research Station (HRS), UHAL, Dakshina Kannada district, Karnataka on 12 February, 2011.

Nayak, M.G. 2011. Improved production technology of cashew for central India including Chhattisgarh. In: Workshop cum Seminar on Present Status, Prospects and Problems of cashew cultivation in Bastar, organized at Jagdalpur during 4-5 January, 2011.

Nayak, M.G. 2011. Prospects and problems of cashew cultivation based entrepreneurship in North East Hill Region. In: National Seminar cum Workshop on Developing the Potential of Underutilized Horticultural crops of Hill Region organized at Imphal by NEH Research Complex for NEH Region during 14-16 February, 2011.

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Nayak, M.G. and Bhat, M.G. 2010. Recent approaches of canopy management and rejuvenation in cashew. **In:** Seminar on cashew organized at ICAR Research Complex for Goa on 21 August, 2010.

Raviprasad, T.N. 2011. Changing scenario of insect-pests of cashew in Central India including Chhattisgarh. **In:** Workshop on Present status, prospects and problems of cashew plantations in Bastar during 4-5 January, 2011.

Rupa, T.R., Yadekumar, N., Vidya, B.R. and Indushree 2010. Effect of biofertilizers on growth of cashew rootstocks and soil properties. **In:** National Seminar on Developments in Soil Science - 75th Annual Convention of the Indian Society of Soil Science at Indian Institute of Soil Science, Bhopal during 14-17 November, 2010.

Yadekumar, N., Rejani, R., Rupa T.R. and Srividya, B.R. 2010. Optimal nutrient requirement and plant density for enhancing the cashew productivity. **In:** 19th Plantation Crops Symposium (PLACROSYM XIX), RRII, Kottayam, Kerala during 7-10 December, 2010.

9.3 Book Chapters

Bhat, M.G. 2010. The Cashew : **In:** Horticulture in Different Agro-climatic Conditions - Four Decades of Coordinated Research (Ed: H.P. Singh and M.S. Palaniswamy) Vol. 1, pp: 117-128. Westville Publication House, New Delhi.

Manjunath, S. Patil and Dinakara Adiga, J. 2011. Strategies for *In vitro* Conservation of Gladiolus using growth retardation techniques. Lambert Academic Publishing, Germany.

Thimmappaiah., Shobha D., Melwyr, G.S. and Santhosh, W.G. 2010. Cashew (Chapter 15). **In:** Advances in Horticulture Biotechnology-Molecular Markers and Marker Assisted Selection - Fruit Crops, Plantation Crops and Spices (Volume III)

(Ed: H.P. Singh., V.A. Parthasarathy and K. Nirmal Babu) Westville Publishing House, New Delhi, 330 pp.

Thimmappaiah, 2010. Cashew (Chapter 21). **In:** Advances in Horticulture Biotechnology - Regeneration systems - Fruit Crops, Plantation Crops and Spices (Volume 1) (Ed: H.P. Singh., V.A. Parthasarathy and K. Nirmal Babu) Westville Publishing House, New Delhi, 463 pp.

Yadekumar, N., Bhat, M.G. and Nayak, M.G. 2010. Technological intervention for organic production of cashew. **In:** Organic Horticulture, Principles, Practices and Technologies. (Ed: H.P. Singh and George V Thomas). pp: 40-48.

9.4 Technical Reports / Compendia / Articles

Directorate of Cashew Research, 2010. Annual Report 2009-10, Puttur, Karnataka, 83 pp.

Directorate of Cashew Research, 2010. Research Highlights 2009-10, Puttur, Karnataka, 28 pp.

All India Co-ordinated Research Project on Cashew, Directorate of Cashew Research, Annual Report 2009-10, Puttur, Karnataka, 110 pp.

Directorate of Cashew Research, 2010. Year Planer 2011-12, Puttur, Karnataka, 4 pp.

Directorate of Cashew Research, 2010. Cashew News, Newsletter, Vol. 15 (1), Jan - Jun 2010, Puttur, Karnataka, 12 pp.

Directorate of Cashew Research, 2010. Cashew News, Newsletter, Vol. 15 (2), Jul - Dec 2010, Puttur, Karnataka, 12 pp.

Nayak, M.G. and Bhat, M.G. 2010. Cashew graft production and nursery management in cashew. Invited paper submitted to Commissioner of Horticulture, Govt. of India.

9.5 Extension bulletins / pamphlets

Nayak, M.G. and Adiga, J. D. 2011. Training and Pruning in Cashew (*Genaragala sevaravike mattu cakara taravike*) (Kannada). Directorate of Cashew Research Extension Handout (Revised), 6 pp.

Nayak, M.G., Bhat, P.S., Raviprasad, T.N. and Adiga, J.D. 2011. Rejuvenation of Cashew Trees (*Genunaragala Punashchetna*) (Kannada). DCR Technical Bulletin (Revised), 6 pp.

Yadukumar, N., Nayak, M.G., Bhat, P.S. and Adiga, J.D. 2011. Improved cashew cultivation (*Sudhaarita Geru Besarya*) (Kannada). DCR Technical Bulletin (Revised), 6 pp.

Yadukumar, N., Bhat, P.S. and Adiga, J.D. 2011. High density planting system and cultivation in cashew (*Geru belevalli ghana saundra besarya*) (Kannada), DCR Technical Bulletin (Revised), 6 pp.

9.6 Technical bulletins

Balasubramanian, D. 2010. Munthiri pathanpachuththal (Cashew processing). In: Mundiriyil Mampadathappatta Melanmai Thozhivil Nupangal (Advanced production technologies and Value addition in Cashew) (Ed: M.S. Anusa Rani, S. Jeeva, V. Ambedkar and P. Viswanathan) Regional

Research Station, Tamil Nadu Agricultural University, Vridhachalam, Cuddalore, Tamil Nadu, 40 pp.

Nayak, M.G. and Bhat, P.S. 2010. Softwood grafting and nursery management in cashew. DCR Technical Bulletin (Revised), 22 pp.

Nayak, M.G., Bhat, P.S. and Raviprasad, T.N. 2011. Cashew cultivation practices. DCR Technical Bulletin (Revised), 4 pp.

Raviprasad, T.N. and Bhat, P.S. 2010. Cashew Stem and Root Borer - A major pest of cashew. DCR Technical Bulletin No. 21, 12 pp (Telugu).

Raviprasad, T.N. and Bhat, P.S. 2010. Cashew Stem and Root Borer - A major pest of cashew. DCR Technical Bulletin No. 22, 12 pp (Kannada).

10. LIST OF ON-GOING RESEARCH PROJECTS

Project No.	Title
I CROP IMPROVEMENT	
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 Ranikesh Meena).
1.7	Molecular characterization of cashew germplasm (Thimmappaiah).
DBT	Identification of molecular markers linked to economic characters in cashew (Thammappaiah).
II CROP MANAGEMENT	
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).
2.12	Rejuvenation of trees of high density cashew orchards through canopy management (M.G. Nayak).
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, P.D. Sreekanth and M.G. Nayak).
2.15	Rootstock studies in cashew (J.D. Adiga and M.G. Nayak).
DBT	Development of INM package for commercially important plantation crops - Microbial inoculant based nutrient management in cashew (T.R. Rupa).
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. Kalavaran).
2.18	Effect of Paclobutrazol on growth and yield of cashew (J.D. Adiga and M.G. Nayak).

III CROP PROTECTION	
3.11	Investigations on insect fauna associated with cashewnuts / kernels (T.N. Raviprasad and P.S. Bhat).
3.13	Studies on sex pheromone of shoot tip caterpillar <i>Hypatima haligraoma</i> M. (Gelechiidae: Lepidoptera) (T.N. Raviprasad).
3.14	Studies on the determination of insecticide residue on cashew apples (P.S. Bhat and T.N. Raviprasad).
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 and T.N. Raviprasad).
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).
Obsv. trial	Evaluation of synthetic fungicides against flowering diseases of cashew (P.S. Bhat).
Network	ORP on Management of sucking pests in Horticultural Crops (ICAR funded through IIR, Bangalore) (P.S. Bhat and T.N. Raviprasad).
IV POST-HARVEST TECHNOLOGY	
4.10	Assessment of bio availability of minerals in cashew (K.V. Nagaraja).
4.11	Design and development of artificial dryer for raw cashewnuts (D. Balasubramanian).
4.12	Studies on alternate energy utilization of cashewnut shell cake (D. Balasubramanian and Sandeep Gald).)
4.14	Development of compact type drum roasting machine for raw cashewnuts (D. Balasubramanian and S.D. Deshpande).
NAP	A value chain on cashew for domestic and export market (Consortium partner: D. Balasubramanian).
V TRANSFER OF TECHNOLOGY AND COMPUTER APPLICATION	
5.1	Transfer of technology programme in cashew (M.G. Naya's, P.S. Bhat, J.D. Adiga and T.R. Rupa).
6.2	Computer application in cashew (P.D. Sreekanth).
6.3	Database for cashew germplasm (P.D. Sreekanth).

11. IMPORTANT MEETINGS AND SIGNIFICANT DECISIONS

11.1 Research Advisory Committee

Prof. D.P. Ray, Vice Chancellor Orissa University of Agriculture and Technology Bhubaneswar 751 003, Orissa.	Chairman
Dr. I. Irulkappan, Former Dean (Horticulture) 28, Abhirami Nagar, Narayanapuram P- Main Road Narayanapuram West, Madurai 625 014, Tamil Nadu.	Member
Dr. M.N. Khare, Ex Dean, JNKVV, Jabalpur 24, Ravindranagar, Adhartal, Jabalpur 482 004, M.P.	Member

Dr. Narendra Kumar, Former Director Directorate of Personnel, DRDO Bhawan, Rajaji Marg New Delhi 110 011.	Member
Dr. P.M. Salimath, Director of Research UAS, Dharwad 580 005, Karnataka.	Member
Dr. S. Rajan, Asstt. Director General (Hort-I) Indian Council of Agricultural Research Krishi Anusandhan Bhavan-II, Pusa, New Delhi 110 012.	Member
Mr. Cyriac John, TC-25/2057 KMR Residency Kunankuzhi Thiruvananthapuram, Kerala.	Non Official Member
Dr. P.M. Haldankar, Professor and Head Department of Horticulture College of Agriculture Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth Dupoli - 415 712, Ratnagiri district Maharashtra.	Non Official Member
Dr. M.G. Bhat, Director Directorate of Cashew Research Puttur - 574 202, Karnataka.	Member
Dr. M.G. Nayak Principal Scientist (Horticulture) Directorate of Cashew Research Puttur - 574 202, Karnataka.	Member-Secretary

Composition of V RAC is w.e.f. 8 December 2008 for three years.

The second meeting of the fifth Research Advisory Committee (RAC) (14th meeting) of the Directorate was held on 8 May, 2010 under the chairmanship of Dr. D.P. Ray, Vice Chancellor, OUAT, Bhubaneswar. He released the Research Highlights of DCR for the year 2009-10. Dr. S. Rajan, ADG

(Horticulture), Dr. Narendra Kumar, Former Director, DRDO, New Delhi and Dr. P.M. Salimath, Director of Research, UAS, Dharwad participated in the meeting and the progress made under the research projects were discussed and recommendations were made.

11.2 Institute Management Committee

Name and Address	Status
Dr. M.G. Bhat, Director, DCR, Puttur - 574 202, DK District, Karnataka.	Chairman
Dr. S. Rajan Assistant Director General (Hort-I), ICAR Krishi Anusandhan Bhavan-II, New Delhi-110 012.	Member
Dr. K.B. Durdi, Joint Director of Horticulture (Plantation Crops and Plant Protection), Directorate of Horticulture, Department of Horticulture, Lalbagh, Bangalore, 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, Udipi 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, Dakshina Kannada, Karnataka.	Member
Dr. S. Arulraj, Project Coordinator (Palms), 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, Retd. Bank Manager Neejibailu House, Manchi Post, Buntwal Taluk, D.K. District, Karnataka.	Member
Senior Finance and Accounts Officer, Central Plantation Crops Research Institute, Kasaragod, Kerala.	
Asst. Administrative Officer, DCR, Puttur - 574 202, D.K. District, Karnataka.	Member

The Institute Management Committee (IMC) met twice on 26 November, 2010 and 25 March, 2011 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.

11.3 Institute Research Committee

The 23rd Institute Research Committee (IRC) was held during 2-3 June, 2010. Dr. M.G. Bhat, Director, DCR and Chairman of the IRC meeting briefed about the progress made in different

research projects. There were technical sessions on "Crop Improvement", chaired by Dr. N. Vijayan Nair, Director, Sugarcane Breeding Institute, Coimbatore, "Crop Management" chaired by Dr. N. Kumar, Dean (Horticulture), TNAU, Coimbatore, "Crop Protection" chaired by Dr. M. Mari, Head & Principal Scientist, IHR, Bangalore, "Post Harvest Technology" chaired by Dr. M.G. Bhat, Director, DCR, "Transfer of Technology and Computer Application" chaired by Dr. Sreenath Dixit, Principal Scientist, CRIDA, Hyderabad. The scientists of the Directorate presented progress made under various projects and technical programme of all the projects was finalized.

11.4 Institute Joint Staff Council (IJSC)

VII IJSC (upto 28 February, 2011)

Official Side	
Dr. M.G. Bhat	Chairman
Dr. J.D. Adiga	Member
Shri. K.M. Jayarama Naik	Member (w.e.f. 1 February, 2010)
Shri. H. Ganesha	Member
Dr. (Mrs) R.Rejani	Secretary
Staff Side	
Shri. R. Muthuraju	Secretary
Shri. K.V. Ramesh Babu	Member (CJSC)
Shri. K.M. Lingaraja	Member
Shri. K. Balappa Gowda	Member
Shri. H. Veerappa Gowda	Member
Shri. K. Umanathu Shetty	Member

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

Official Side	
Dr. M.G. Bhat	Chairman
Dr. M.G. Nayak	Member
Dr. T.N. Raviprasad	Member
Shri. K.M. Jayarama Naik	Member
Shri. H. Ganesha	Member (upto 25 March, 2011)
Shri. K.M. Lingaraja	Member (w.e.f. 26 March, 2011)
Dr. D. Kalaiyannan	Secretary
Staff Side	
Smt. K. Padmini Kutty	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.

11.5 राजभाषा कार्यान्वयन समिति

1.	डॉ. एम.जी. भट्ट	अध्यक्ष
2.	डॉ. टी.एन. रविशंकर	सदस्य
3.	डॉ. टी.आर. रूपा	सदस्य
4.	श्री रामकेश नीणा	सदस्य
5.	श्री लक्ष्मीपती	सदस्य
6.	श्री प्रकाश जी. भट्ट	सदस्य
7.	श्री के. सीताराम	सदस्य
8.	श्रीमति के. रेष्मा	सदस्य
9.	श्री रविशंकर प्रसाद	सदस्य
10.	श्रीमति पद्मिनि कुट्टी	सदस्य
11.	श्री के.एन जयराम नायक	सदस्य सचिव

वर्ष 2010-11 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 छठे वार्षिक कार्यक्रम के अनुसार निश्चित लक्ष्य दिया गया था उन लक्ष्यों के प्राप्ति के लिए की जा रही कार्रवायों के बारे में भी चर्चा किया गया। अनेक निर्णय भी लिए गए।

हिन्दी में कार्यालयीन कार्य करनेवालों को प्रोत्साह देने की दृष्टि से पुरस्कार योजना जारी है। 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 की प्रशिक्षण के लिए कोशिश जारी है।

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

पुलूर नगर राजभाषा कार्यान्वयन समिति (नराकास)

काजू अनुसंधान निदेशालय, पुलूर नगर राजभाषा कार्यान्वयन समिति (नराकास) की संयोजक कार्यालय है। यह निदेशालय पुलूर नराकास की 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 जनवरी में, पुलूर नगरकास की दो अर्धवार्षिक बैठकें आयोजित हुईं। इन बैठकों में पुलूर 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 माह 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 पखवाड़ा 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। संयोजक कार्यालय में, सदस्य कार्यालय के सभी कर्मचारियों को हिन्दी सीखने के लिए जरूरी सुविधा दिया जा रहा है।

12. PARTICIPATION IN SYMPOSIA / CONFERENCES / SEMINARS / MEETINGS

Nayak, M.G.	National Consultancy on Biodiversity organized by NBPGR, New Delhi.	26-27 April, 2010.
Bhat, M.G.	XXII Meeting of ICAR Regional Committee No. VIII and Interactive Session on Krishi Vigyan Kendras scheduled at Indian Veterinary Research Institute, Regional Station, Hebbal, Bangalore.	28-30 May, 2010.
Bhat, M.G. Nayak, M.G.	Swadesh Prem Jagriti Sangosti 2010 and National Conference on Horticultural Biodiversity for Livelihood, Economic Development and Health Care held in Bangalore jointly organized by Lt. Arjit Singh Foundation, New Delhi and UHS, Bangalore.	13-15 May, 2010.
Belasubramanian, D.	Meeting of Officers of Plantation Corporation of Kerala (PCK) at Head Office, PCK, Calicut, Kerala and presented Perspectives of Cashewnut Processing in India.	5 June, 2010.
Bhat, M.G. Nayak, M.G. Bhat, P.S.	Meeting in connection with DUS related works pertaining to cashew being organized by Protection of Plant Varieties and Farmers' Right Authority, Ministry of Agriculture, Govt. of India at CPCRI, Kasaragod.	28-29 June, 2010.
Bhat, M.G.	Participated in ICAR Directors' Conference including ICAR Foundation Day Celebrations in NASC Complex, New Delhi.	15-16 July, 2010.
Bhat, M.G. Raviprasad, T.N.	Visited cashew growing areas in northern coastal regions of Andhra Pradesh for selecting sites suitable for shifting the AICRP Cashew Centre from CRS Bapatla under APIIU.	1-2 August, 2010.
Bhat, M.G.	149 th Board Meeting of KCDK Ltd. held in the Registered Office of KCDK Ltd., at Mangalore.	18 August, 2010.
Nayak, M.G. Raviprasad, T.N.	State Level Seminar on "New Challenges in Cashew Production under Current Trends of Climate Changes" organised at ICAR Research Complex, Goa.	21 August, 2010.
Bhat, M.G. Rupa, T.R.	Participated in the Second Interactive Meeting on Nutrient Dynamics of Horticultural Crops held at NRC Citrus, Nagpur.	27-28 September, 2010.
Bhat, M.G.	Participated in the brainstorming workshop on Emerging Issues of Agriculture Research and Education in Chhattisgarh at IGAC, Raipur and participated in the discussions.	29 September, 2010.
Bhat, P.S.	Krishinade organized at Zonal Agricultural Research Station (ZARS), Brahmanavar, Udupi district, Karnataka.	9 October, 2010.
Bhat, M.G.	Participated in the National Consultative Meet on Bioinformatics in Horticulture (Hortinformatics 2010) at IISR, Kozhikode.	11-12 October, 2010.
Aciga, J.D.	Sensitization cum training workshops for nodal officers of PIMS-ICAR held at NAARM, Hyderabad.	25 October, 2010.
Bhat, M.G. Nayak, M.G.	Participated in the International Conference on Coconut Biodiversity for Prosperity held at CPCRI, Kasaragod.	25-28 October, 2010.
Bhat, M.G.	Participated in the Interactive meeting on Linkages and collaboration between different institutes and XII Five Year Plan proposals and Horticulture - Industry Meet held at IHR, Bangalore.	10-11 November, 2010.
Nayak, M.G.	Interactive Meeting of Horticulture and Industries organized by IIM and IHR, Bangalore.	10-11 November, 2010.

Bhat, M.G.	Participated in the Interface Meeting of Crop Science, Horticulture and Natural Resource Management Divisions of ICAR to discuss various issues related to data sharing, management, strengthening and integration of databases in the Lecture Hall of NASC Complex, Pusa, New Delhi.	23-24 November, 2010.
Bhat, M.G. Rupa, T.R. Balasubramanian, D. Rejani, S.	Participated in 19 th Plantation Crops Symposium (PLACROSYM XIX) at Rubber Research Institute of India, Kottayam, Kerala.	7-10 December, 2010.
Bhat, M.G. Nayak, M.G.	Participated in the Global Conference on "Meeting the Challenges in Banana and Plantain for Emerging Biotic and Abiotic Stresses" at Truchirapalli, Tamil Nadu organized by NRC Banana, Truchirapalli.	11-12 December, 2010.
Nayak, M.G. Raviyasod, T.N.	Workshop on Present status, prospects and problems of cashew plantations in Bastar at Agriculture College, Jagdalpur.	4-5 January, 2011.
Bhat, M.G. Nayak, M.G.	Participated in X Agriculture Science Congress on Soil, Plant and Animal Health for Enhanced and Sustained Agricultural Productivity held in National Bureau of Fish Genetic Resources (NBFGR), Lucknow organized by NAAS and NBFGR and CISH, Lucknow.	10-11 February, 2011.
Nayak, M.G.	National Seminar cum Workshop on Development of Potential of Underutilized Horticultural Crops of Hill Region organized by ICAR Res. Complex for NEH, Manipal Centre, Imphal.	14-16 February, 2011.
Bhat, M.G.	Participated in the Training Programme on Employers' Perspective on Labour Related Laws held at NAARM, Hyderabad.	17-19 February, 2011.
Nayak, M.G.	State level Seminar on Cashew organized at RRS, Vridhachalam, Tamil Nadu.	24 February, 2011.
Bhat, M.G.	Attended Directors' Conference and Interface Meeting of Vice Chancellors of SAUs and Directors at New Delhi.	23-24 February, 2011.
Bhat, M.G.	Attended the Discussion Meeting of Directors with DDG (IT) on 8 March, 2011 and Interoffice Meeting of Chairmen of RACs and Directors of Institutes of Horticulture Division on 9 March, 2011 at New Delhi.	8-9 March, 2011.
Nayak, M.G.	Consultative Workshop on Strategies and Formulation of Forest Genetic Resources Management Network (FGRMN) organized at Institute of Forest Genetics and Tree Breeding, Coimbatore.	9-10 March, 2011.
Adiga, J.D.	Meeting of R/D nodal officers of ICAR Institutions held at NASC, New Delhi.	11-14 March, 2011.
Balsubramanian, D.	Executive Council Meeting of Indian Society for Plantation Crops (ISPC), as elected member of executive council, for the period from 2010-12 at CPCRI, Kasargod.	20 January, 2011.
Bhat, P.S.	Geniela organized at Horticultural Research Station (HRS), Uthal, Dakshina Kannada district, Karnataka.	12 February, 2011.
Balsubramanian, D.	Meeting of officers of NABARD organized by Central Plantation Crop Research Institute, Kasargod, Kerala at Directorate of Cashew Research, Puttur, Karnataka and delivered lecture on "Indian Cashew processing System".	1 March, 2011.
Balsubramanian, D.	Annual Meeting cum Workshop of ZTMU-BPD, convened by Central Institute of Fisheries and Technology, Cochin, Kerala and presented "Activities of ITMU at Directorate of Cashew Research, Puttur".	4-5 March, 2011.
Balsubramanian, D.	Annual Review Meeting of NAIP conducted at University of Agricultural Sciences, Dharwad, Karnataka.	15-16 March, 2011.

13. FARMERS' DAY / KRISHI MELA / CAMPAIGNS / CONSULTANCY / SPECIAL ASSIGNMENT

Bhat, P.S.	Krishi mela organized at Zonal Agricultural Research Station (ZARS), Brahmasar, Udupi district, Karnataka.	9 October, 2010.
Nayak, M.G. Bhat, P.S.	Visited cashew orchards established by tribal farmers with guidance from BAH, Pune (DRUVA in Gujarat and MITTRA in Maharashtra) for offering consultancy.	19-22 December, 2010.
Bhat, P.S.	Gen. mela organized at Horticultural Research Station (HRS), Ujal, Dakshina Kanara District, Karnataka.	12 February, 2011.

14. DELEGATION / TRAINING

Nayak, M.G.	Training on Establishment of National Information Sharing Mechanism on the Implementation of the Global Plan of Action for the Conservation and Sustainable utilization of Plant Genetic Resources for Food and Agriculture in India organized at NBPGR, New Delhi.	17 April, 2010.
Nayak, M.G.	Training on Establishment of National Information Sharing Mechanism on the Implementation of the Global Plan of Action for the Conservation and Sustainable utilization of Plant Genetic Resources for Food and Agriculture in India organized at NBPGR (RS) Thiruvananthapuram.	19 May, 2010.
Sreekanth, P.D.	Training programme on Strengthening Statistical Computing for NARS held at IAS, GKVK, Bengaluru.	9 August - 16 September, 2010.
Kalavanna, D.	92 nd Foundation Course for Agricultural Research Service (92 nd FOCARS) at National Academy of Agricultural Research Management (NAARM), Hyderabad.	1 September - 29 December, 2010.
Raveerasud, T.N.	Participated in the training programme on Leveraging Innovation for Scientists and Technologists (LIST) organised by the Institute of Management Training and Research (IMTR), Dona Paula, Panaji, Goa.	10-15 October, 2010.
Raveerasud, T.N.	Participated in the Sensitization Training Workshop on Bioinsecticides and its various applications under NAIP - NABCI at National Bureau of Agriculturally Important Insects, Bengaluru.	8-12 November, 2010.
Rupe, T.R.	Training programme on Agricultural Drought: Climate Change and Rainfed Agriculture at Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad.	20 January - 9 February, 2011.
Balsubramanian, D.	Training programme conducted by KVK, Mangalore to Self Help Group (SHG), Mangalore (Delivered a lecture on Utilization of Cashew Apple and demonstrated preparation of cashew apple products).	23 February, 2011.

15. RADIO TALK / INTERVIEW/ TV PROGRAMMES

i) RADIO TALK / INTERVIEW

Bhat, P.S.	Recording a radio talk on the topic "Tea Mosquito Bug in Cashew and it's Management" at All India Radio, Mangalore.	28 March, 2011.
Raviprasad, T.N.	Recording a radio talk on the topic "Cashew Stem and Root Borer and it's Management" at All India Radio, Mangalore.	28 March, 2011.

ii) TV PROGRAMMES

Nayak, M.G.	A TV interview on "Varieties of Cashew" at ARS, Jagdalpur in Hindi language.	8 January, 2011.
Bhat, P.S. Raviprasad, T.N.	Participated in Phone - in - Programme on the topic "Management of tea mosquito bug and cashew stem and root borer in cashew" telecast by Chandana Kannada Channel of Doordarshan, Bengaluru.	23 February, 2011.
Bhat, M.G.	Recording of a programme "Cashew Scenario and Improved Cashew Varieties" - by Chandana Kannada Channel of Doordarshan, Bengaluru.	24 March, 2011 (telecast on 26 April, 2011).
Bhat, P.S.	Recording of a programme "Tea Mosquito Bug in Cashew and it's Management" - by Chandana Kannada Channel of Doordarshan, Bengaluru.	24 March, 2011.
Raviprasad, T.N.	Recording of a programme "Cashew Stem and Root Borer and it's Management" - by Chandana Kannada Channel of Doordarshan, Bengaluru.	24 March, 2011.
Nayak, M.G.	Recording of a programme "Nursery management in cashew" by Chandana Kannada Channel of Doordarshan, Bengaluru.	25 March, 2011.
Nayak, M.G.	Recording of a programme "Training and pruning in cashew" by Chandana Kannada Channel of Doordarshan, Bengaluru.	25 March, 2011.
Adiga, J.D.	Recording of a programme "Planting and after care" - by Chandana Kannada Channel of Doordarshan, Bengaluru.	25 March, 2011.
Balasubramanian, D.	Recording of a programme "Processing of cashew apple and nut" - by Chandana Kannada Channel of Doordarshan, Bengaluru.	25 March, 2011.

16. DISTINGUISHED VISITORS

Dr. N.K. Tyagi Member Agricultural Scientists Recruitment Board, New Delhi - 110 012.	22 September, 2010.
Dr. Jose C. Samuel Chief Consultant (NHM) Ministry of Agriculture Krishi Bhavan New Delhi - 110 001.	18 October, 2010.

17. PERSONNEL

Managerial

Director

Dr. M.G. Bhat

17.1 Scientific

Discipline	Scientist	Scientist (Sr. Scale)	Sr. Scientist	Pr. Scientist	Total (Incl. Vacant Posts)
Agricultural Engg. (AS&PE)	—	—	D. Balasubramanian	—	1
Agricultural Entomology	—	—	T.N. Raviprasad Vacant-1 post	P.S. Bhat	3 (1)
Agri. Extension	Vacant-1 pos.	—	—	—	1 (1)
Biochemistry (Pl.Sci.)	—	—	K.V. Nagaraja (upto 31 Oct. 2010) Vacant-1 post	—	1 (1)
Biochemistry	—	—	—	Thimmappaiah (Gen. & Cyto.)	1
Computer Application	—	P.D. Sreekanth	—	—	1
Genetics and Cytogenetics	Vacant-1 post	—	Vacant-1 post	—	2 (2)
Horticulture	Ramkesh Meena*	—	J.D. Adiga Vacant-1 post	M.G. Nayak	4 (1)
Plant Physiology	Vacant-1 post	—	—	—	1 (1)
Soil Science	D. Kalivannan (from 28 April, 2010)	—	—	N. Yakkumar (Agronomy) (upto 30 April, 2010)	1
Soil and Water Cons. Engg.	—	R. Rejani	—	—	1
Soil Science - Soil Physics and soil and water conservation	—	—	—	T.R. Rupa	1
Total	5 (3)	2	7 (4)	4	18 (7)

* On study leave for Ph.D.

Figures in the parentheses indicate no. of vacant posts.

17.2. Technical

- | | |
|------------------------------|------------------------------------|
| 1. Sri. K. Munalokrishna | Farm Superintendent T (7-8) |
| 2. Sri. P. Achulla | 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. Praakash G. Bhat | Technical Officer (T-6) |
| 6. Sri. N. Munikundan | Technical Officer (T-5) |
| 7. Sri. R. Muthuraju | Technical Officer (Computer) (T-5) |
| 8. Sri. K. Seetharama | Technical Officer (T-5) (Farm) |

9.	Sri. Lakshmiipathi	Technical Officer (T-5)
10.	Sri. R. Lakshmiha	Technical Officer (T-5)
11.	Sri. K.V. Ramesh Babu	Technical Officer (T-5)
12.	Sri. Vijay Singh	Technical Assistant (T-3)
13.	Sri. A. Poovappa Gowda	Technical Assistant (T-4)
14.	Sri. Ravishankar Prasad	Technical Assistant (T-2)
15.	Sri. K. Babu Poojary	Technical Assistant (T-2)
16.	Sri. Bejmi Veigas	Technical Assistant (T-2)
17.	Sri. K. Umaath	Technical Assistant (T-2)
18.	Sri. P. Honappa Naik	Technical Assistant (T-1)

17.3. Administration

1.	Sri. H. Ganesha	Assistant Finance and Accounts Officer
2.	Sri. K.M. Jayarama Naik	Assistant Administrative Officer (Stores)
3.	Sri. K.M. Lingaraju	Assistant Administrative Officer
4.	Sri. O.G. Varghese	Private Secretary
5.	Ms. B. Jayashree	Personal Assistant
6.	Ms. K. Reshma	Junior Stenographer
7.	Ms. M. Ratna Ranjani	Assistant
8.	Ms. Winne Lobo	Assistant
9.	Ms. M. Leela	Assistant
10.	Sri. Umashankar	LDC
11.	Ms. K. Padmini Kutty	LDC
12.	Sri. K. Balappa Gowda	Gesture Operator

18. MISCELLANEOUS

18.1 Visitors

Visitors (around 1000) 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.

18.2 Consultancies

A team of two scientists visited the cashew orchards established by tribal farmers with guidance from BAIF, Pune (DRUVA in Gujarat and MITTRA in Maharashtra) during 19-22 December, 2010. They studied the situation and conditions of cashew orchards in Dang and Valsad districts of South Gujarat and Nasik district of Maharashtra and offered consultancy for the improvement of cashew orchards and the production.

18.3 Average weather data (2010-11)

Month	Temperature (°C)		Humidity (%)		Rainy days	Rainfall (mm)	Sunshine hours (h)	Evaporation (mm)
	Max.	Min.	FN	AN				
Apr. 10	37.1	23.7	90	48	5	80.8	7.4	5.1
May 10	36.6	23.4	90	51	4	145.2	5.6	3.8
Jun. 10	32.1	22.9	96	85	30	819.7	2.7	3.3
Jul. 10	30.8	22.9	97	90	29	1149.9	1.2	2.7
Aug. 10	30.5	22.9	96	90	24	647.9	1.5	2.8
Sep. 10	31.8	22.7	96	79	22	467.6	2.6	3.3
Oct. 10	32.4	22.6	96	74	15	257.5	4.6	3.9
Nov. 10	33.7	22.2	95	66	12	360.5	5.3	4.0
Dec. 10	34.2	19.0	94	57	2	53.6	7.1	4.5
Jan. 11	36.1	16.0	92	47	0	0.0	9.1	5.0
Feb. 11	36.8	17.5	90	43	0	0.0	9.2	5.4
Mar. 11	38.0	21.4	91	39	0	0.0	7.4	5.6
						3982.7		

18.4. List of DCR publications

Sl. No.	Publication	Price (Rs.)
1	Cashew production technology (Revised)	50.00
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	<i>Sulbaritha guru besaya kranogala</i> (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

Price indicated above does not include postage.

Address your enquiries to the Director, DCR, Puttur - 574 202, D.K., Karnataka.

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