

वार्षिक प्रतिवेदन ANNUAL REPORT 2009 - 10



काजू अनुसंधान निदेशालय

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

DIRECTORATE OF CASHEW RESEARCH

(Indian Council of Agricultural Research)
Darbe P.O., Puttur - 574 202,
Dakshina Kannada, Karnataka



ISSN. 0972-2637

वार्षिक प्रतिवेदन ANNUAL REPORT 2009-'10

काजू अनुसंधान निदेशालय

(भारतीय कृषि अनुसंधान परिषद्)

दर्वे पोस्ट, पुत्तूर - 574 202, दक्षिण कन्नड, कर्नाटक



DIRECTORATE OF CASHEW RESEARCH

(Indian Council of Agricultural Research)

Darbe P.O., Puttur - 574 202,

Dakshina Kannada, Karnataka



Correct Citation

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

Published by

Dr. M.G. Bhat

Director

Directorate of Cashew Research

Puttur - 574 202

Tel No : 08251-231530 (O), 230992(R), 233490 (R)

EPABX: 08251-230902, 236490

Fax : 08251 - 234350

Gram : CAJUKENDRA

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

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

Compiled and edited by

Dr. K.V. Nagaraja

Dr. P. Shivarama Bhat

July 2010

Word processed by

Mr. R. Muthuraju

Hindi Translation

Dr. T.N. Raviprasad

Hindi Text

Mr. Prakash G.Bhat

Cover Photo : **Cashew apples of a promising accession.**

Printed at:

Codeword Process and Printers

Yeyyadi, Mangalore- 575008, Phone: 09900100818, 0824-2214618

Contents

	PAGE NO.
प्रस्तावना	4
PREFACE	5
कार्यकारी सारांश	6-7
EXECUTIVE SUMMARY	8-9
INTRODUCTION	10-13
RESEARCH ACHIEVEMENTS	15-63
1. CROP IMPROVEMENT	16-20
2. CROP MANAGEMENT	21-32
3. CROP PROTECTION	33-37
4. POST-HARVEST TECHNOLOGY	38-39
5. TRANSFER OF TECHNOLOGY	40-42
6. CONCLUDED PROJECTS	43-63
ADDITIONAL INFORMATION	65-83

प्रस्तावना

मुझे काजू अनुसंधान निदेशालय, पुत्तूर, का वार्षिक प्रतिवेदन 2009-10 प्रस्तुत करने में खुशी होता है जिसमें अप्रैल 2009 से मार्च 2010 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 उसमें पाये गये परिणामों तथा उपलब्धियों का इस वार्षिक प्रतिवेदन में प्रस्तुत की गई है। अण्डमान और निकोबार से संग्रहित चैदह संग्रहणों को राष्ट्रीय काजू क्षेत्रीय जीन बैंक (NCFGB) में रोपण करने से संरक्षित जननद्रव्य एक्सशनों का संख्या 527 तक बढ गया है। बडे गुटलीवाली हैब्रीडो H-43 और H-125 क्रमश 5.0 तथा 5.2 कि.ग्रा. / पेड का अधिक उपज तथा 30.1 और 31.7 कि.ग्रा./पेड का छः कटाई का संचयी उपज दिया। खुल 67 जननद्रव्य एक्सशनों को RAPD, ISSR व SSR मार्करों से फिंगर प्रिंटिंग किया गया। NRC 372 तथा NRC 369 एक्सशनों अत्यंत विभिन्न थे। ISSR मार्करों से किये गये “क्लस्टर अनालिसिस” से 12 क्लस्टरो का पता चला। सधन पौध रोपण प्लाटो (416 तथा 500 पेड/हे) की संचयी उपज (6.52 तथा 7.16 टन/हे) सार्थक रूप से सामान्य रोपण प्लाटों का उपज (4.29 टन / हे) से अधिक रहा। प्रमुख पोषकांश H_3PO_4 (0.5%) का पर्णीय फुहार से अत्यधिक संख्या का द्विलिंगी पुष्प (16.94%) उत्पन्न हुआ, जबकी लघु पोषकांश $ZnSO_4$ (0.5%) + सालूबोर (0.1%) का फुहार से पुष्पगुच्छ की संख्या तथा गुटली उपज / पेड सार्थक रूप से अधिक रहा। काजू कांड तथा जड छेदक (CSR) का भृगों का छोटी इल्ली अवस्ता से पूर्णतः अर्ध - कृत्रिम आहार (Semi Synthetic Diet) में पालन करके इस साल, प्रप्रथमतः प्रौढ भृगों को पाया गया। न्यूक्लियोटाइड अनुक्रम की जाँच से जीववर्गीकरण अध्ययनों से चाय मच्छर का दो प्रभेदो, यानि हेलोपेल्टीस आन्टेनी तथा प्याकीपेल्टीस मीसारम मे स्पष्ट भिन्नता पाया गया। प्रमुख खनिजो जैसे लोह (Fe), ताम्र (Cu) म्यांगनीस (Mn), जस्त (Zn) और सेलेनियम (Se) का जीवलभ्यता का प्रमाण चर्बी निकालति काजू गरी आटा, मेथेनॉल सारनिकासत काजू सेव - चूर्ण और काजू गरी छिलके में विविध किस्मो के बीच में सार्थकरूप से विभिन्न रहा। इस निदेशालय ने DCCD, कोच्चि तथा विविध विकास विभागों से अपना सहभागित्व जारी रखकर तकनीकी हस्तांतरण कार्यक्रमों में बुलंदी लाया है। इस निदेशालय में सफलतापूर्णक रूप से वार्षिक काजू दिवस आयोजित किया जिसमें कर्नाटका तथा केरला का अधिकारियों ने भाग लिए। इस साल में इस निदेशालय ने अनेक राजस्तर तथा राष्ट्रस्तरीय प्रदर्शनों में काजू उत्पादन तकनीकी से संबंधित प्रविधियों का प्रचार करने के लिये भाग लिया।

मैं वर्ष 2009-10 में पायी गई उपलब्धियों को संकलन करने के लिए संपादकीय समिति के सदस्यों को आभारी हूँ।

स्थल : का. अ. नि., पुत्तूर
दिनांक : 3 जूलै, 2010

एम. गोपालकृष्ण भट्ट
(एम. गोपालकृष्ण भट्ट)
निदेशक

PREFACE

I am happy to present the Annual Report 2009-'10 of Directorate of Cashew Research, Puttur covering the progress of the Directorate for the period from April 2009 to March 2010. The scientists of the Directorate have taken up the projects in the areas of Crop Improvement, Crop Management, Crop Protection, Post-Harvest Technology and Transfer of Technology as per the approved technical programme and results and achievements of these projects are furnished in this Annual Report.

The germplasm accessions conserved in the National Cashew Field Gene Bank (NCFGB) have risen to 527 with the planting of fourteen collections from Andaman and Nicobar Islands and Meghalaya. Hybrids, H - 43 and H-125 with bold nuts continued to yield higher (5.0 and 5.2 kg /tree respectively) with a cumulative yield of 30.1 and 31.7 kg /tree respectively for six harvests. A total of sixty seven germplasm accessions were fingerprinted with RAPD, ISSR and SSR markers. The accessions NRC 372 and NRC 369 were found highly divergent. Cluster analysis conducted with ISSR markers distinguished 12 clusters. The cumulative yield in the high tree density plots (416 and 500 trees/ha) was significantly more (6.52 and 7.17 t/ha) than in normal tree density plot (4.29 t/ha), eight years after planting. Foliar spray application of major nutrient, H_3PO_4 (0.5%) resulted in production of the highest number of bisexual flowers (16.94%) while, the application of secondary micronutrients in the form of $ZnSO_4$ (0.5%) + solubor (0.1%) significantly increased number of panicles, and nut yield/tree. Adult beetles of Cashew Stem and Root Borer (CSRB) could be obtained for the first time, by rearing entirely on the Semi-Synthetic Diet (SSD) from nascent stage (immediately after hatching). The biosystematics studies revealed the clear dissimilarity between two species of tea mosquito bug, namely, *Helopeltis antonii* and *Pachypeltis maesarum* when comparison of sequence of nucleotides was made. The extent of bioavailability of important minerals like iron (Fe), copper (Cu), manganese (Mn), zinc (Zn) and selenium (Se) in defatted cashew kernel flour, methanol extracted cashew apple powder and cashew kernel testa of released varieties varied significantly with respect to varieties. The Directorate continued its collaboration with DCCD, Kochi, and Development Departments for strengthening Transfer of Technology programmes. The Directorate has successfully organized Annual Cashew Day and officials of Karnataka and Kerala participated actively in this programme. During the year the Directorate has participated in several State and National level exhibitions for disseminating the technologies on Cashew Production Technology.

I am thankful to members of Editorial Committee for compiling the Annual Report 2009-10.

Place : Puttur
Date : 3rd July 2010


(M. Gopalakrishna Bhat)
Director

कार्यकारी सारांश

काजू अनुसंधान निदेशालय में 2009-10 में एक DBT परियोजना, एक जाँच शुल्क परीक्षण, एक NAIP परियोजना और तीन अवलोकनार्थ परीक्षण सहित कुल मिलाके 32 परियोजनाओं प्रचालित थे। इस साल, अण्डमान तथा निकोबार द्वीप तथा मेघालय से इसके पहले संग्रहित चौदह संग्रहणों को राष्ट्रीय काजू क्षेत्रीय जीन बैंक (NCFGB) में रोपण करने से NCFGB में संग्रहित एकसशनों का संख्या 527 तक पहुँचा है। आशाजनक हैब्रीडो H-43 और H-125 से 5.0 और 5.2 कि.ग्रां. / पेड का वार्षिक उपज इस साल में मिला और छः साल का संचयी उपज क्रमशः 30.1 तथा 31.7 कि.ग्रां. / पेड रहा। RAPD, ISSR तथा SSR मार्करों के उपयोग से 67 जननद्रव्य एकसशन का “फिंगरप्रिंटिंग” किया गया। जकार्ड समानरूप गुणांक संख्या दो एकसशनों के बीच अनुमानित किया गया, जो 0.38 - 0.89 तक की श्रेणी में रहा और औसत समानरूपता 0.60 होकर एकसशनों के बीच कम भिन्नता सूचित किया। तथापि, एकसशनों NRC-372 और NRC-369 तीव्ररूप से भिन्न रहा। ISSR मार्करों से किये गये गुच्छ विश्लेषण से 12 गुच्छ पहचाना गया। सधन पौध रोपण प्लाटो (416 तथा 500 पेड / हे) की संचयी उपज (6.52 तथा 7.17 टन / हे) सार्थरूप से सामान्य रोपण प्लाटों का उपज (4.29 टन / हे) से अधिक रहा। 10 x 5 मी अतरालन प्लाटो से मिली संचयी काजू गुटली उपज की तुलना में 5 x 4 मी का प्लाटो से मिली उपज 67 प्रतिशत ज्यादा रहा जबकी 6 x 4 मी का प्लाटो से मिली उपज 52 प्रतिशत ज्यादा रहा। प्रमुख पोषकांश H_3PO_4 (0.5%) का पर्णिय फुहार से अत्यधिक संख्या का द्विलिंगी पुष्प (16.94%) उत्पन्न हुआ। लघु पोषकांश $ZnSO_4$ (0.5%) + सालुबोर (0.1%) का फुहार से पुष्पगुच्छ की संख्या तथा गुटली उपज / पेड सार्थकरूप से अधिक था। काजू के विस्तीर्ण पहचानने के लिए "Erdas Imagine" नामक दूरवर्ती संवेदी साफ्टवेर को

इस्तमाल करके बंजर जमीन, पेडपौधे इत्यादी का विंबो का प्रारंभिक वर्गीकरण किया गया।

काजू कांड तथा जड छेदक (CSRB) का भृगों का छोटी इल्ली अवस्था से संपूर्णतः अर्ध - कृत्रिम आहार (semi-synthetic diet) में पालन करके इस साल प्रप्रथमतः प्रोढ भृगों को पाया गया। चाय मच्छर नियंत्रण की वड़ा प्लाट परीक्षों में फेनप्रोपाथ्रीन ((0.02%) शिफारित कीटनाशक λ - सैहालोथ्रीन (0.003%) से बराबर क्षमता दिखाई। फेनप्रोपाथ्रीन का लाभ - खर्च अनुपात λ - सैहालोथ्रीन से तुलनीय रहा। K_2SO_4 (1%) फुहार किये गये प्लाटो में चाय मच्छर का आपतन कम रहा और हानि गुणांक 0.14 से 1.54 तक रहा। न्यूक्लियोटैड अनुक्रम की जाँच से जीववर्गीकरण अध्ययनों में चाय मच्छरों का दो प्रभेदों यानि हेलेपेल्टीस ऑटोनी तथा प्याकिपेल्टीस मीसारम में स्पष्ट भिन्नता पाया गया। विविध जगहो से संग्रहित हेलेपेल्टीस ऑटोनी का नमूनो में पाया गया भिन्नता सार्थक नहीं रहा।

चर्वी निकालित काजू गरी आटा, मेथेनॉल सारनिष्कासित काजू सेव चूर्ण और काजू गरी छिलके में लोहा (Fe), ताम्र (Cu) म्यांगनीस (Mn), जस्त (Zn) और सेलेनियम (Se) जैसे प्रमुख खनिजों का जीवलभ्यता के बारे में अध्ययन किया गया। कच्छा काजू गुटली सुखानेवाली ड्रैय्यर का परिरूप, विकास और मूल्यांकन के बारे में अध्ययन लिया गया है। वाष्प / ड्रम सेंकना विधान से प्राप्त काजू छिलका खली का वैकल्पिक शक्ति उपयोगों के बारे में भी अध्ययन जारी रहा। इसे कार्वनीकृत ब्रिकेट बनाकर काजू उपउत्पन्न का मूल्य वृद्धि की जा सकती है। यांत्रिकृत सेंकना एकक जिसमें भरण, सेंकन तथा शीतलन आदि तीन क्षेत्र रहनेवाला कल्पनक विन्यास परिष्कृत किया गया है और लघु - टैप ड्रम सेंकन मशीन का निर्माण CIAE भोपाल के सहयोग में प्रचालित है।

इस साल मृद कांड कलमन, नर्सरी प्रबंधन तथा काजू उत्पादन तकनीकी की बारे में श्रीक्षेत्र धर्मस्थला ग्रामीण विकास परियोजना (SKDRDP), धर्मस्थला, BAIF विकास अनुसंधान फौंडेशन (DRUVA एकक, गुजरात तथा MITTRA एकक, महाराष्ट्र) तथा बागवानी विभाग, आंध्र प्रदेश के अधिकारीयों को प्रशिक्षण आयोजित था कुटुंबश्री, कासरगोड तथा कृषि तकनीकी प्रबंधन एजन्सी (ATMA), कण्णुर के महिलावो के लिए “काजू संस्करण” के वार में प्रशिक्षण आयोजित था । इस निदेशालय का तकनीकी मार्गदर्शन तथा काजू और कोको विकास निदेशालय, कोच्ची की आर्थिक सहायता से प्रचालित प्रदर्शनी प्लाट होनेवाली कृषकों की सह-भागित्व में दिनांक 4

मार्च 2010 को वार्षिक काजू दिवस आयोजित किया गया । इसमें कर्नाटका और केरला के लगभग 300 कृषकों ने भाग लिया । इस निदेशालय अनेक राज्यस्तरीय और राष्ट्रस्तरीय प्रदर्शनों में काजू उत्पादन तकनीकी के संबंधित प्रविधियों को प्रचार करने के लिए भाग लिया । इस निदेशालय ने उत्तम उपज देनेवाली किस्मो का कलमन तैय्यार करके कृषकों तथा राष्ट्र के विकास विभागों को वितरित किया है ।

इस निदेशालय में प्रचालित और समाप्त अनुसंधान परियोजनाओं से प्राप्त परिणामों का सारांश इस वार्षिक प्रतिवेदन में प्रस्तुतीकृत है ।



EXECUTIVE SUMMARY

A total of 32 projects including one DBT project, one paid up trial, one NAIP project and three observational trials were in operation at Directorate of Cashew Research during 2009-10. During this year, fourteen collections made earlier from Andaman and Nicobar Islands and Meghalaya were planted in the National Cashew Field Gene Bank (NCFGB) bringing the total number of accessions conserved in NCFGB to 527. The promising hybrids, H - 43 and H-125 yielded 5.0 and 5.2 kg/tree during the year with a cumulative yield of 30.1 and 31.7 kg/tree respectively for six harvests. Sixty seven germplasm accessions were fingerprinted with RAPD, ISSR and SSR markers. The Jaccard's similarity coefficient values estimated between pair of accessions varied from 0.38-0.89 with an average similarity of 0.6 indicating low diversity existing among the accessions. However, accessions NRC 372 and NRC 369 were found highly divergent. Cluster analysis conducted with ISSR markers distinguished 12 clusters.

The cumulative yield in the high tree density plots (416 and 500 trees/ha) was significantly more (6.52 and 7.17 t/ha) than in normal tree density plot (4.29 t/ha) eight years after planting. The cumulative cashew nut yield was found to be 67 per cent more in plots of spacing 5m x 4m and 52 per cent more in plots of spacing 6m x 4m compared to normal density with a spacing of 10mx5m. Among the foliar spray of major nutrient, H₃PO₄ (0.5%) spray resulted in production of the highest number of bisexual flowers (16.94%). Application of secondary micronutrients in the form of ZnSO₄ (0.5%) + solubor (0.1%) significantly increased number of panicles, and nut yield/tree. Using remote sensing software, "Erdas Imagine", preliminary classification of images for vegetation and barren area has been completed with a view to determine area under cashew.

Adult beetles of Cashew Stem and Root Borer (CSRB) could be obtained for the first time, by rearing

entirely on the Semi-Synthetic Diet (SSD) from nascent stage (immediately after hatching). In a larger plot evaluation, fenprothrin (0.02%) was on par with recommended insecticide λ - cyhalothrin (0.003%) in the management of tea mosquito bug (TMB). The benefit: cost ratio for fenprothrin was also comparable with λ - cyhalothrin. The incidence of TMB was lower in K₂SO₄ (1%) sprayed plots and the damage score ranged from 0.14-1.54. The biosystematics studies revealed the clear dissimilarity between two species of tea mosquito bug, namely, *Helopeltis antonii* and *Pachypeltis maesarum* when comparison of sequence of nucleotides was made. The variation between the samples of *Helopeltis antonii* collected from different locations, however, was not significant.

The bioavailability of important minerals like iron (Fe), copper (Cu), manganese (Mn), zinc (Zn) and selenium (Se) in defatted cashew kernel flour, methanol extracted cashew apple powder and cashew kernel testa of released varieties was studied. The extent of bioavailability varied significantly with respect to varieties and minerals. Studies have been taken up on design, development and evaluation of dryer for raw cashewnut. Studies also have been carried out on alternative energy utilization of cashew shell cake obtained from steam / drum roasting process. It can be converted into carbonized briquette for value addition to cashew by-product. A conceptual design of mechanized roasting unit consisting of three different zones viz., feeding, roasting and cooling zones has been refined and fabrication of compact type drum roasting machine for raw cashewnuts is under progress in collaboration with CIAE, Bhopal.

During the year, training programmes on softwood grafting and nursery management and cashew production technology were organized for the officials of Shree Kshethra Dharmasthala Rural Development Project (SKDRDP), Dharmasthala ; BAIF Development

Research Foundation (DRUVA unit of Gujarat and MITTRA unit of Maharashtra) and Department of Horticulture, Andhra Pradesh. Training programme on "Cashew Processing" was conducted for women from Kerala belonging to Kudumbashree, Kasaragod and Agricultural Technology Management Agency (ATMA) Kannur. The Annual Cashew Day was organized on 4th March 2010 in association with farmers maintaining demonstration plots as per the technical guidance of this Directorate with the funds from Directorate of Cashewnut and Cocoa Development. This was attended

by around 300 farmers and officials from Karnataka and Kerala. The Directorate has participated in several State and National level exhibitions for disseminating the technologies on Cashew Production Technology. The Directorate has produced and distributed grafts of high yielding varieties to farmers and Development Departments of the country.

The summary of results of the on-going and concluded research projects of the Directorate are presented in this Annual Report.



INTRODUCTION

Research on cashew was first initiated in the early 1950s. Indian Council of Agricultural Research (ICAR), sanctioned adhoc schemes for Research Centres located at Kottarakkara (Kerala), Ullal (Karnataka), Bapatla (Andhra Pradesh), Daregaon (Assam) and Vengurle (Maharashtra). In 1971, ICAR also sanctioned All India Coordinated Spices and Cashew Improvement Project (AICS and CIP) with its Headquarters located at CPCRI, Kasaragod. The CPCRI Regional Station, Vittal (Karnataka) was given the mandate to carryout research work on cashew while four University Centres (Baptala, Vridhachalam, Anakkayam and Vengurle) were assigned the research component on cashew under AICS and CIP. During the V and VI plan periods three more Centres (Bhubaneswar, Jhargram and Chintamani) came under the fold of AICS and CIP and with shifting of work of Anakkayam Centre to Madakkathara. The recommendations made by the Quinquennial Review Team (QRT) constituted by ICAR in 1982, Working Group on Agricultural Research and Education constituted by the Planning Commission for VII Plan Proposals and the Task Force on Horticulture constituted by ICAR resulted in the establishment of National Research Centre for Cashew at Puttur on 18th 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 90m above MSL).
- The main campus has an area of 68 ha with field experiments and Laboratory-cum-Administrative Block, Conference Hall, Library and Engineering Workshop. 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 with field experiments.
- 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, CROPCD, PLANTGENE CD and TROPAG CD are also available in the library. The library is equipped with automation software and bar-coding facility. The library has 1171 books and 1601 back volumes of various journals. The library subscribes for 33 National and 14 International Journals. The library is a member of Consortium of Electronic Resources on Agriculture (CeRA), New Delhi. Tech - Focuz digital library software is also available for CD Database search.
- The Headquarters of AICRP on Cashew is located at DCR Cashew, Puttur. It has ten

Coordinating Centres and a Sub-Centre 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. There are three Co-operating Centres in Arabhavi (Karnataka), Old Goa (Goa) and Barapani (Meghalaya).

SIGNIFICANT ACHIEVEMENTS

- The Directorate has the largest germplasm collection of cashew in the country (National Cashew Field Gene Bank) with 527 accessions. A total of 433 cashew accessions have been assigned with National Collection numbers. The Conservation Block of Gene Bank has been established with 362 evaluated accessions by planting four plants of each accession.
- It has released three varieties, namely, NRCC Sel-1, NRCC Sel-2 and Bhaskara, which are high yielding and medium nut types for cultivation in Karnataka.
- Regeneration of cashew from the seedling explants (nodal cultures) has been standardized.
- Micrografting technique for *in vitro* multiplication of cashew has been standardized.
- Protocols have been standardized for characterization of released varieties and cashew germplasm accessions using RAPD, ISSR and SSR markers.
- The Directorate has demonstrated the advantage of growing intercrops like pineapple, turmeric, brinjal, chillies and amorphophallus profitably in cashew gardens.
- Glyricidia grown as an intercrop during initial years, contributed 5.75 t/ha of dry matter, equivalent to 186 kg N, 40.8 kg P₂O₅ and 67.8 kg K₂O/ha. The yield of cashew increased by 50 per cent when glyricidia and sesbania were raised as green manuring crops compared to control. Glyricidia, is however, recommended as the best green manure crop due to its perennial nature.
- Application of 200g of biofertilizer (Azospirillum sp.) / plant with 33 kg of compost of recyclable cashew biomass resulted in 12 per cent higher yield 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 an yield increase by 2.5 times over control in the initial ten years.
- Irrigating cashew at 60-80 litres of water/tree once in four days through drip after initiation of flowering till fruit set and development in combination with the application of 750: 187.5: 187.5 g of NPK/tree led to significant higher yields.
- Individual tree terracing with crescent bund is the best soil and water conservation measure in slopy lands. Soil and water conservation techniques like modified crescent bund or staggered trenches with coconut husk burial treatments helps in conserving soil moisture, reducing the annual runoff / soil loss and increasing the nut yield.
- Drip irrigation and fertigation requirements have been standardised for normal (200 trees/ha) planting system. 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 is feasible for the commercial multiplication.
- 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. Lambda

- cyhalothrin (0.003%) is 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 sugar/honey and 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 a 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.

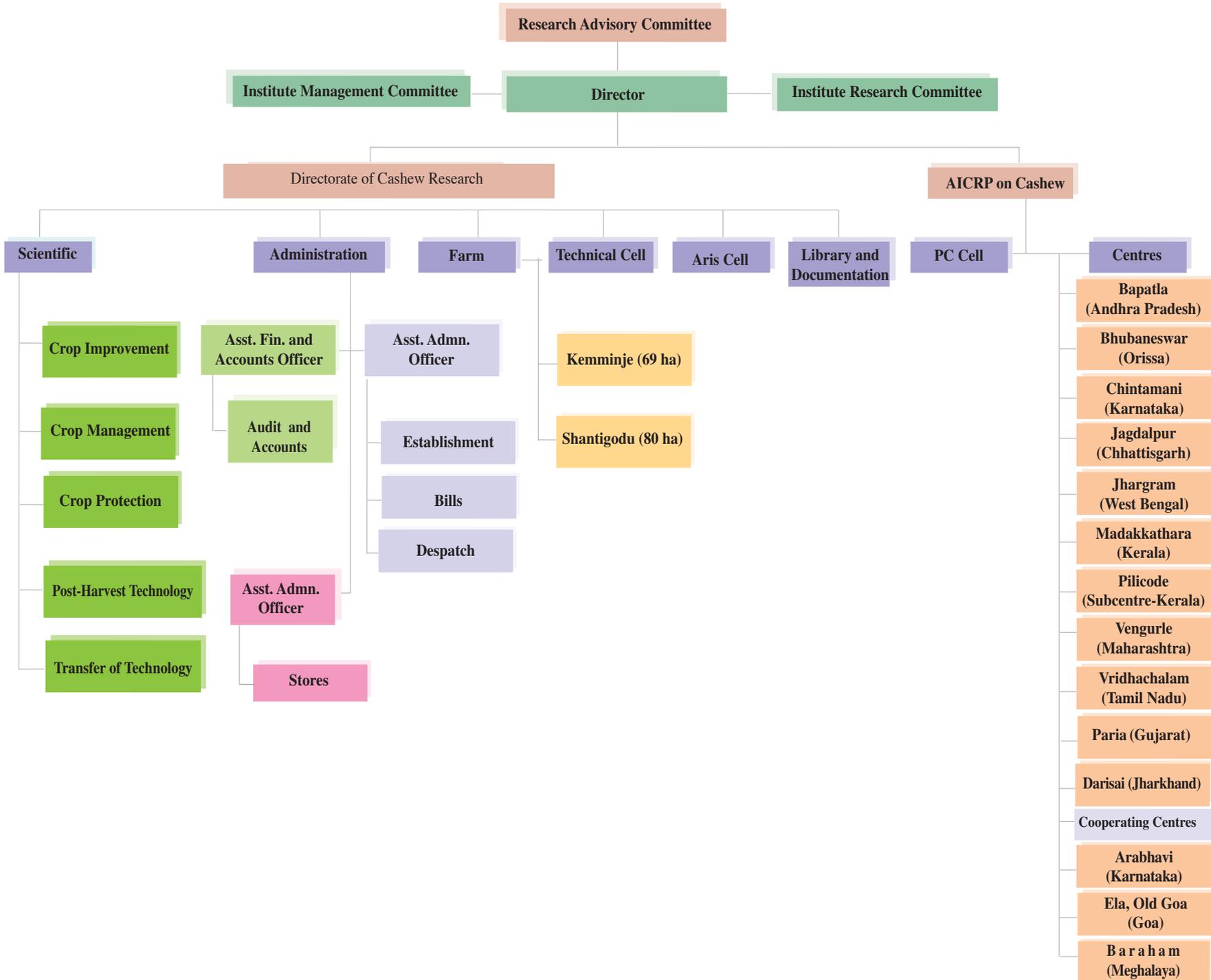
BUDGET (2009-'10) (RS. IN LAKHS)

Plan	Non-Plan	External	Total
125.00	386.08	6.53	517.61

STAFF POSITION AS ON 31.3.2010

Category	NON PLAN		
	Sanctioned	Filled	Vacant
Director (RMP)	1	1	-
Scientific	18	12	6
Technical	19	17	2
Administrative	14	12	2
Skilled Supporting	39	36	3
Canteen	1	1	-
Total	92	79	13

ORGANISATIONAL SETUP OF DCR, PUTTUR



RESEARCH ACHIEVEMENTS

1. CROP IMPROVEMENT

1.1 Genetic resources of cashew

1.1.1 Germplasm conservation

Fourteen germplasm accessions collected from Andaman and Nicobar Islands and Meghalaya during the year 2008-09 were clonally multiplied and planted (6 plants/accessions at 6M x 6M) in National Cashew Field Gene Bank (NCFGB) bringing the total germplasm collections conserved so far at NCFGB to 527.

Forty two accessions evaluated during 2008-09 were clonally multiplied and planted in Conservation Block of NCFGB at a closer spacing of 4M x 4M (4 plants/accession). The total accessions conserved so far in the Conservation Block is 362.

1.1.2 Germplasm evaluation

Observations on the 29 germplasm accessions planted during 1998-99 has been completed. Among the 29 germplasm accessions evaluated, majority (19) are upright growing and intensive and upright branching and all had medium internodal length. All the 29 accessions were highly spreading types due to extensive growth of twigs. All the accessions had red coloured young leaves and 24 of them had green coloured matured leaves with mango like odour. Among the accessions characterized, 28 had smooth leaf margin and 19 accessions had round apex leathery texture with medium sized leaves. Majority (25) were mid season flowering types with pyramidal shaped inflorescence (27) and cream coloured flowers and the sex ratio was medium in 20 accessions. Secondary flowering was not observed in any of the evaluated 29 accessions. Twenty eight accessions had high flowering intensity and medium duration of flowering. Among the evaluated accessions 17 had yellow coloured apple with smooth

and glossy skin, and majority (15) had big size apple with intermediate attachment to apple. All the accessions had low cumulative yield with kidney shaped grey coloured nuts. Twenty of them had intermediate shell thickness with high shelling percentage. Kernel weight was medium and loose peel attachment to kernel (Table 1.1).

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 (cross combinations of NRCC Selection-2 x Bhutnath-II), H-125 and H-126 (cross combinations of NRCC Selection-2 x Bhedasi) yielded 5.0, 4.5, 5.0, 5.2 and 4.9 kg/tree, respectively with a cumulative yield of 30.13, 28.36, 29.00, 31.65 and 28.69 kg /tree, respectively for six harvests.

1.2.2 Seedling selection in cashew

Growth parameters with respect to seedling progenies of NRCC Selection-2, V-4, VRI-3, Bhaskara, VTH-174 and VTH-30/4 were recorded. The average plant height ranged from 283 cm to 321.75 cm. The trunk girth ranged from 22.81 cm to 27.37 cm. The canopy spread ranged from 220.5 cm to 310.5 cm and varied significantly among the progenies (Table 1.2).

1.2.3 Performance of promising hybrids in replicated trial

The grafted plants of promising hybrids varied significantly for plant height and stem girth while canopy spread did not vary among hybrids. The average plant height ranged from 175 cm to 406.25 cm. The stem girth ranged from 15.5 cm to 29.16 cm. The canopy spread ranged from 237.66 cm to 389.75 cm (Table 1.3).

Table 1.1: Characteristics of 29 accessions characterised during 2009 fruiting season as per IPGRI Descriptors

Data field	Descriptor	Descriptor State	No. of Accessions
07	Tree habit	3 Upright and Compact	19
		5 Upright and Open	10
		7 Spreading	0
08	Leaf size	3 Short <1.0 cm	0
		5 Medium > 1.0 - 2.0 cm	29
		7 Long > 2.0 cm	0
10	Tree height	3 Dwarf < 2.5 M	0
		5 Semitall 2.5 - 4.0 M	0
		7 Tall < 4.0 M	29
11	Tree spread	3 Low < 3.0 M	0
		5 Intermediate 3.0 - 6.0 M	0
		7 High > 6.0 M	29
15	Extension growth of twig	3 Short < 9.0 cm	0
		5 Medium > 9.0 - 19.0 cm	6
		7 Long > 19.0 cm	23
16	Branching pattern	1 Extensive	7
		2 Intensive	22
19	Colour of young leaves	1 Red	29
		2 Yellow red	0
		3 Green yellow	0
		4 Purple	0
20	Colour of mature leaves	1 Light green	0
		2 Green	24
		3 Dark green	5
		4 Purple	0
21	Colour of leaves	1 Mango-Like	29
		2 Turpentine	0
22	Leaf margin	1 Smooth	28
		2 Wavy	1
28	Season of flowering	3 Early (Nov - Dec)	2
		5 Mid (Dec - Jan)	25
		7 Late (Jan - Feb)	2
29	Inflorescence shape	3 Narrowly Pyramidal	0
		5 Pyramidal	27
		7 Broadly Pyramidal	2
30	Flower colour	1 White	0
		2 Cream	29
		3 Pink	0
31	Mature cashew apple colour	1 Yellow	17
		2 Red	3
		3 Yellow Red	9
		4 Red Purple	0
32	Cashew apple shape	1 Cylindrical	15
		2 Conical Obovate	9
		3 Round	3
		4 Pyriform	2

33	Colour of mature nut shell	1	Buff	0
		2	Grey	29
		3	Purple	0
34	Nut shape	1	Kidney	29
		2	Oblong ellipsoid	0
35	Nut weight	3	Low (< 5g)	3
		5	Intermediate (5 - 7 g)	9
		7	High (> 7g)	17
50	Attachment of nut to apple	3	Loose	5
		5	Intermediate	16
		7	Tight	8
57	Shell thickness	3	Thin (< 2.5 mm)	9
		5	Intermediate (2.5 - 4.0 mm)	20
		7	Thick (> 4.0 mm)	0
60	Flowering duration	3	Short (< 60 days)	2
		5	Medium (60 - 90 days)	27
		7	Long (> 90 days)	0
61	Flowering intensity	3	Low (< 40%)	0
		5	Medium (40.0 - 70.0%)	1
		7	High (> 70.0%)	28
63	Shelling percentage	3	Low (< 18.0%)	0
		5	Intermediate (18.0 - 28.0%)	7
		7	High (> 28.0%)	22
65	Attachment of peel to kernel	3	Loose	29
		7	Tight	0
68	Cumulative yield	3	Low (< 9 Kg)	29
		5	Medium (9 - 18 Kg)	0
		7	High (> 18 Kg)	0

Table 1.2: Performance of seedling progenies for growth characters

Variety	Plant height (cm)	Stem girth (cm)	Canopy spread (cm)
NRCC Selection-2	283.00	22.81	243.00
V-4	295.00	24.43	232.25
VRI-3	297.50	24.62	310.50
Bhaskara	300.00	27.37	250.75
VTH-174	283.75	24.37	220.50
VTH 30/4	321.75	24.31	293.25
F- test	NS	NS	**
CD (5%)	-	-	46.25

Table 1.3: Performance of promising hybrids in replicated trial

Hybrid/ Variety	Plant height (cm)	Stem girth (cm)	Canopy spread (cm)
H-43	300.00	24.22	345.33
H-66	258.22	21.00	287.66
H-68	345.83	27.83	389.75
H-125	286.11	26.66	356.25
H-126	328.47	23.14	295.27
H-1250	264.58	19.94	276.94
H-2452	175.00	15.50	237.66
H-2473	280.55	22.44	336.11
NRCC Sel-2 (check)	245.69	21.30	328.47
Bhaskara (check)	406.25	29.16	363.75
F-test	**	*	NS
CD (5%)	82.95	7.36	-

1.3 Molecular characterization of cashew germplasm

Sixty seven accessions of cashew representing collections mostly from Karnataka were finger printed using ISSR and SSR markers. ISSR analysis was carried out with eight selected ISSR primers which generated a total of 58 bands of which 50 were polymorphic (86.2%) and produced on an average 7.2 polymorphic bands per primer. Among the primers used, UBC 857 was highly informative. The similarity coefficient values (Jaccard's) estimated between pair of accessions varied from 0.38-0.89 with an average of 0.6 indicating low diversity existing among the accessions. Among the accessions, NRC 372 and NRC 369 were, however, found highly divergent. Cluster analysis conducted with ISSR markers could distinguish 12 clusters.

Similarly, SSR analysis was carried out in 67 accessions with 10 SSR primer pairs of cashew which generated 22 bands on high resolution agarose (3.5%) (SFR agarose) in which 20 were polymorphic (90.9%) and produced on an average two polymorphic bands per primer. Among the primers used, CS 14 was highly

informative. The similarity coefficient values (Jaccard's) between pair of accessions varied from 0.25-1.00 with an average of around 0.6 again indicating low diversity among the accessions studied. The "UPGMA" dendrogram drawn based on similarity values of SSR markers could distinguish 14 clusters. Among the accessions, NRC 394, NRC 400 and NRC 388 were highly divergent.

Markers data (130) of RAPD, ISSR and SSR were also combined and analyzed. The polymorphism of markers was 87.7% and the similarity coefficient varied from 0.52 to 0.83. Average similarity of around 0.6 even with combined markers indicated low diversity. However, by combined markers NRC 344 and NRC 388 were found highly divergent.

1.4 Identification of molecular markers

Phenotypic evaluation of F₂ progeny of cross V-5 X VTH 711/4 for various characters was carried out along with compilation of phenotypic data (Descriptor data) of 177 germplasm. Germplasm was sorted based on their high and low phenotypic values to constitute bulks for various important characters.

In germplasm, 12 DNA bulks were constituted for six characters namely plant height, fruit weight, flowering duration, nut weight, shelling percentage and cumulative mean yield. These bulks were screened with 85 RAPD, 29 ISSR and 16 SSR primers and observed polymorphism with 30 RAPD (37.5%), 17 ISSR (58.6%) and 6 SSR (37.5%) primers.

Validation carried out with individuals of bulks with 17 RAPD polymorphic primers could identify only three putative markers for nut size (UBC 184, UBC 185, OPN 14,) and one for plant height (UBC 185). No marker could be confirmed in the individuals of bulk with SSR of cashew. SSR primers from other species (chillies, almond) showed poor amplification while in mango no marker could be identified (Fig.1.1).

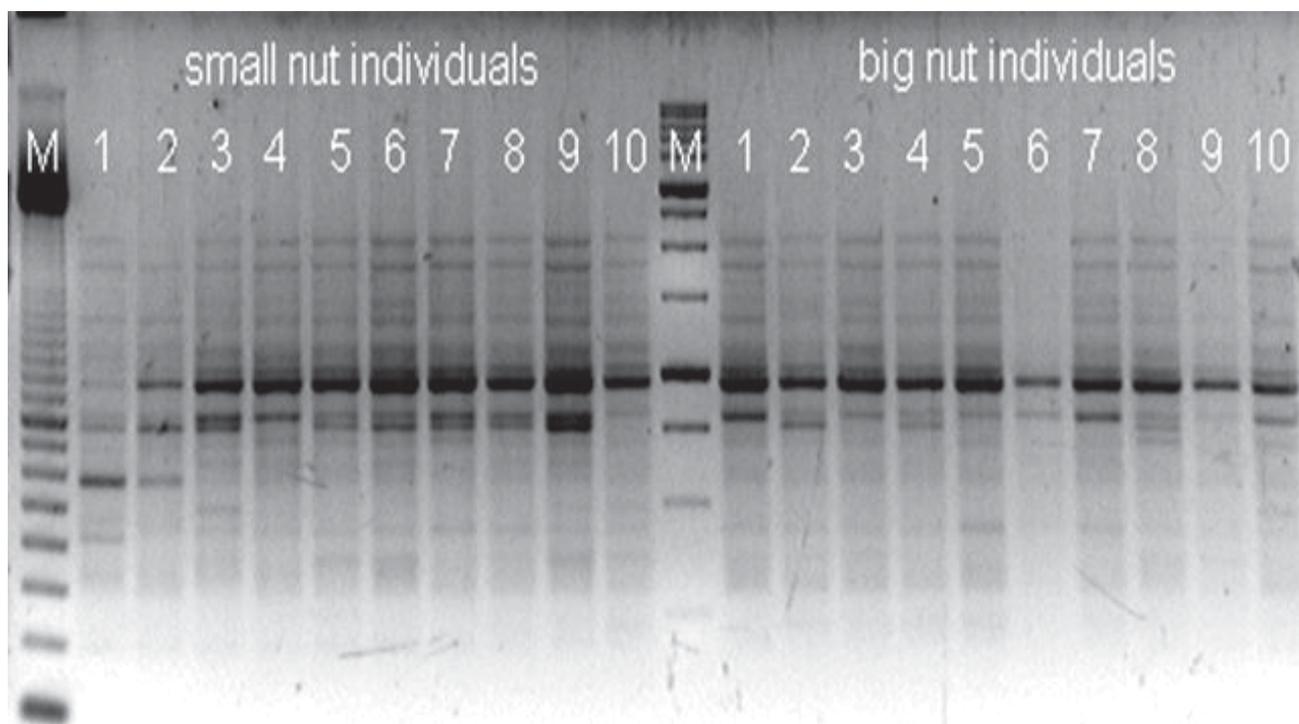


Fig 1.1: RAPD marker (OPN 14₇₇₅) for low nut weight

2. CROP MANAGEMENT

2.1 Nutrient requirement and pruning trials in high density cashew plantations

The experiment was planted in 2001 with three 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) and 225 kg N, 75 kg each of P₂O₅ and K₂O (M3) as sub plots.

2.1.1 Effect of tree density on yield and growth of cashew

During 2009-'10, the yield in the high tree density plots (416 and 500 trees/ha) was significantly more (2.18 and 2.43 t/ha) than in normal tree density plot (1.95 t/ha) eight years after planting (Table 2.1). Significant difference in yield was not observed with increase in manure from M1 to M3. Interaction effect between tree density and fertilizer levels was also not observed.

The cumulative yield in the high tree density plots (416 and 500 trees/ha) was significantly higher (6.52

and 7.16 t/ha) than in normal tree density plot (4.29 t/ha) eight years after planting (Table 2.2). The cumulative cashew nut yield was found to be 67% more in plots of spacing 5m x 4m and 52% more in plots of spacing 6m x 4m compared to normal density with a spacing 10m x 5m. The growth of cashew in different treatments is recorded. Significant difference in yield was not observed with increase in manure from M1 to M3. Interaction effect between tree density and fertilizer levels was also not observed.

2.1.2 Effect of tree density on soil moisture content

The soil moisture content at three different depths (0-30, 30-60 and 60-90cm) was determined at the base of the plant within 1m radius and in the middle of four plants using TDR Soil Moisture Profiling System. The soil moisture content at the base of the plant during February and March 2010 under high density was higher at the lower layers (10 to 17.1 % on dry basis) compared to normal density planting system (10m x 5m, 9.1 to 11.4% on dry basis). Similar trend was observed in the case of soil moisture in the middle of four plants.

Table 2.1: Cashew nut yield (t/ha) under different fertilizer and spacing (2009-10)

Treatment (trees/ha)	M1	M2	M3	Mean	% of control
S1-200	2.35	1.44	2.06	1.95	100
S2-416	1.70	2.47	2.39	2.18	112
S3-500	2.61	2.50	2.17	2.43	125
Mean	2.22	2.14	2.21		
CD(5%)-Main Plot					0.178
CD(5%)-Sub Plot					NS

Table 2.2: Cumulative cashew nut yield (t/ha) under different fertilizer and spacing (2004-10)

Treatment (trees/ha)	M1	M2	M3	Mean	% of control
S1-200	4.53	3.76	4.58	4.29	100
S2-416	6.09	6.51	6.97	6.52	152
S3-500	7.7	7.41	6.39	7.18	167
Mean	6.11	5.89	5.98		

For the first eight years, maintaining a spacing of 5 m X 4 m (500 plants/ha) is the best compared to spacing of 6m x 4m (400 plants/ha) or 10 m x 5 m (200 plants/ha) for nut yield. Soil moisture content at the surface of the soil is significantly higher in 500 plants/ha than in 200 plants/ha.

2.2 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

2.2.1 Spatial data base preparation using Arc GIS

The soil moisture contents upto 90 cm depth from different plots were determined during December 2010, January 2010 and February 2010 using TDR soil moisture profiling system. During February 2010, in the irrigated plots of integrated nutrient management, the soil moisture ranged from 20 to 21% (on dry basis) in the upper layer and 16.2 to 18.8% on dry basis in the lower layer. In control plot without irrigation, it was 12% (on dry basis). Before fertilizer and manure application, soil samples at two different depths (0-30 cm and 31-60 cm) from 16 plots of Shanthigodu Farm, DCR were analyzed for nutrients and the spatial

database was prepared using "Arc GIS software". The organic carbon content of soil at a 0-30 cm depth varied from 0.54 to 0.76%. The organic carbon content at 31-60 cm depth varied from 0.21 to 0.42% whereas, in fertigated plot it was 0.66%. The organic carbon content ranged from low to medium.

The spatial data base of elevation of the DCR Farm and surrounding area was prepared using "Arc GIS software". The topography of the Farm (from elevation data of >1000 points) is undulating with an elevation varying from 41 to 145 m above MSL with a downward slope towards Kumardhara river (Fig. 2.1).

2.2.2 Remote Sensing using "Erdas Imagine"

The IRS P6 LISS IV MX data with a spatial resolution of 5.8 m (February 2009) and LISS III data with a spatial resolution of 23.5 m (November 2006) were procured from NRSC, Hyderabad. Preliminary classification of images for determining the area under cashew, other vegetation, barren area etc have been done using Remote Sensing software, "Erdas Imagine" for an area of 20000 ha (LISS IV) and 80000 ha (LISS III). The crop suitability studies also initiated. The distribution of cashew in India using the available data, prepared using "Arc GIS" is shown in Fig.2.2

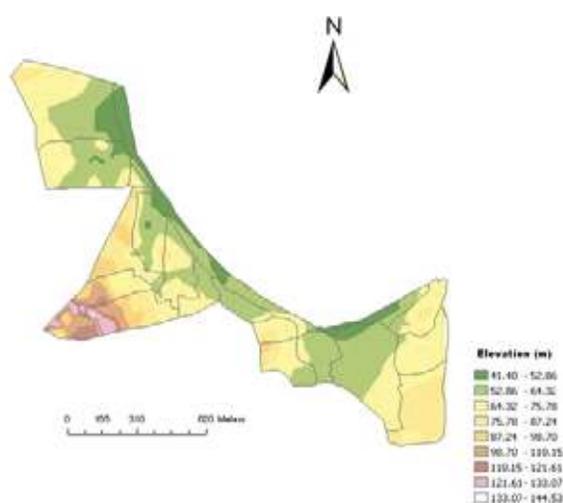


Fig.2.1: The spatial data of elevation (DCR Farm)

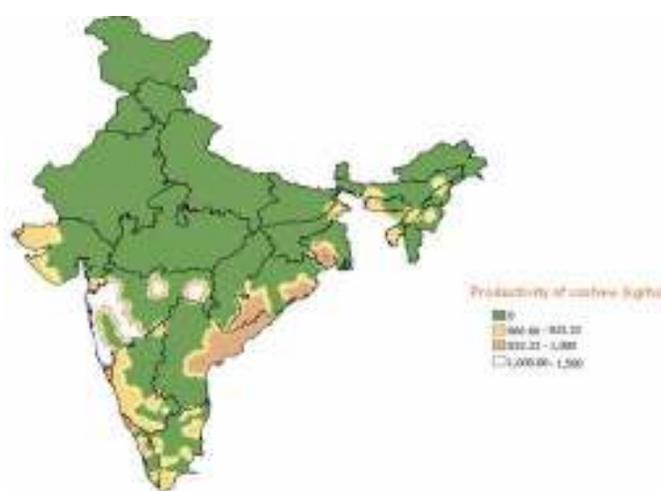


Fig.2.2. The spatial data of cashew grown area in India using "Arc GIS"

2.3 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 leaf nutrient status, growth parameters, fruit set, yield and quality of cashew. Two experiments (Expt. 1: Foliar spray of major nutrients on cashew and Expt. 2: Foliar spray of secondary and micronutrients on cashew) were laid out in RBD with three replications on nine year old cashew trees (NRCC Sel-2) of uniform size at the experimental farm of the Directorate of Cashew Research, Puttur, Karnataka. The plants were spaced at 5 x 5 m. There were four trees in each treatment. All the plants were fertilized with 500 g N, 125 g P₂O₅, 125 g K₂O and 10 kg FYM per plant per year. The plants were sprayed thrice with the foliar fertilizers during flushing, flowering and nut development stages as furnished below:

Experiment I: Foliar spray of major nutrients on cashew

1. Urea 3%
2. H₃PO₄ 0.5%
3. K₂SO₄ 1%
4. Urea 3% + H₃PO₄ 0.5%
5. Urea 3% + K₂SO₄ 1%
6. H₃PO₄ 0.5% + K₂SO₄ 1%
7. Urea 3% + H₃PO₄ 0.5% + K₂SO₄ 1%
8. Control

Experiment II: Foliar spray of secondary and micronutrients on cashew

1. ZnSO₄ 0.5%
2. Solubor 0.1%
3. MgSO₄ 0.5%
4. ZnSO₄ 0.5% + Solubor 0.1%
5. ZnSO₄ 0.5% + MgSO₄ 0.5%
6. Solubor 0.1% + MgSO₄ 0.5%
7. ZnSO₄ 0.5% + Solubor 0.1% + MgSO₄ 0.5%
8. Control

2.3.1 Pre-trial soil fertility status

Soil samples 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 prior to the commencement of foliar nutrition treatments were analysed. The organic carbon content was high. Available P was low, while available K was low to medium and available Fe, Mn and Cu were sufficient. Available Zn and B were deficient. Organic carbon, available P, K, Fe, Mn and B showed a decreasing trend with depth. An increase in content of Zn with depth was noted. Copper did not show any specific trend with soil depth (Table 2.3).

2.3.2 Pre-trial leaf nutrient status

Index leaves (4th and 5th matured leaves) sampled prior to the commencement of foliar nutrition treatments were analysed for N, P, K, Fe, Mn, Zn and Cu. The leaf nutrient concentrations were almost similar for all trees.

Table 2.3: Properties of the experimental soils

Soil property	Soil depth (m)			
	0-0.30		0.31-0.60	
	Expt. 1	Expt. 2	Expt. 1	Expt. 2
Organic carbon (g/kg)	7.9	8.5	3.4	4.4
Available P (kg/ha)	17.5	19.1	8.3	8.9
Available K (kg/ha)	133.4	146.5	86.1	90.2
Available Fe (mg/kg)	32.6	37.8	10.7	11.1
Available Mn (mg/kg)	22.2	25.0	6.5	7.3
Available Zn (mg/kg)	0.26	0.25	0.31	0.33
Available Cu (mg/kg)	0.61	0.58	0.55	0.60
Available B (mg/kg)	0.21	0.24	0.14	0.14

The concentration of N, P and K in index leaves ranged from 1.62 to 1.74, 0.14 to 0.18 and 0.74 to 0.81 per cent, respectively. The concentration of Fe, Mn, Zn and Cu ranged from 30.5 to 38.6, 20.5 to 26.8, 15.2 to 19.5 and 8.1 to 12.3 ppm, respectively (Table 2.4).

2.3.3 Effect of foliar nutrition on growth, nut yield and flower production

In both the experiments, foliar application of nutrients did not show significant difference in the growth parameters such as girth, plant height and canopy spread. There was no significant difference in

the number of panicles produced per tree due to foliar application of major nutrients (Expt. 1). Foliar spray of major nutrients increased the nut yield per tree as compared to the untreated plants but it was statistically non-significant. Foliar spray of secondary and micronutrients increased significantly the number of panicles/tree as well as nut yield/tree, compared to the untreated plants. Higher number of panicles/tree (242) number of nuts/tree (180) and nut yield/tree (1.67 kg) were obtained by application of 0.5% ZnSO₄ + 0.1% solubor spray compared to other treatments tested in this study (Table 2.5, 2.6).

Table 2.4: Leaf analysis prior to the commencement of foliar nutrition spray

Treatment	N (%)	P (%)	K (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)
Urea (3%)	1.68	0.15	0.79	31.5	22.3	16.9	9.0
H ₃ PO ₄ (0.5%)	1.70	0.16	0.74	35.0	20.8	19.5	9.4
K ₂ SO ₄ (%)	1.74	0.17	0.79	38.6	25.4	15.2	8.8
Urea + H ₃ PO ₄	1.66	0.14	0.81	34.4	20.8	18.7	8.1
Urea + K ₂ SO ₄	1.62	0.14	0.80	35.0	24.8	17.1	10.5
H ₃ PO ₄ + K ₂ SO ₄	1.66	0.18	0.74	30.5	25.6	15.5	11.8
Urea + H ₃ PO ₄ + K ₂ SO ₄	1.71	0.15	0.79	36.2	26.8	18.0	12.5
Control	1.70	0.18	0.75	38.0	32.1	17.4	9.3
CD (5%)	NS	NS	NS	NS	NS	NS	NS

Table 2.5: Effect of foliar spray of major nutrients on growth and yield of cashew

Treatment	Girth (cm)	Total height (cm)	Canopy spread (cm)	No. of panicles/tree	No. of nuts/tree	Nut yield kg/tree
Urea (3%)	32.5	353	410	185	159	1.42
H ₃ PO ₄ (0.5%)	36.3	341	422	168	168	1.46
K ₂ SO ₄ (%)	36.5	359	450	170	151	1.38
Urea + H ₃ PO ₄	33.7	396	439	182	162	1.44
Urea + K ₂ SO ₄	36.8	387	464	174	148	1.27
H ₃ PO ₄ + K ₂ SO ₄	38.5	341	447	191	165	1.45
Urea + H ₃ PO ₄ + K ₂ SO ₄	31.7	368	462	192	154	1.37
Control	32.2	354	412	170	145	1.31
CD (5%)	NS	NS	NS	NS	NS	NS

Table 2.6: Effect of foliar spray of secondary and micronutrients on growth and yield of cashew

Treatment	Girth (cm)	Total height (cm)	Canopy spread (cm)	No. of panicles/tree	No. of nuts/tree	Nut yield kg/tree
ZnSO ₄ (0.5%)	31.2	353	436	180	152	1.39
Solubor (0.1%)	35.9	360	412	230	174	1.56
MgSO ₄ (0.5%)	37.1	345	428	212	162	1.46
ZnSO ₄ +Solubor	34.6	381	445	242	180	1.67
ZnSO ₄ + MgSO ₄	35.9	374	438	203	172	1.61
Solubor+MgSO ₄	36.4	392	422	198	158	1.44
ZnSO ₄ +MgSO ₄ +Solubor	34.8	384	410	235	174	1.61
Control	32.2	362	415	186	115	1.05
CD (5%)	NS	NS	NS	27.2	18.6	0.20

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 presented in Fig. 2.3 and 2.4 clearly showed a considerable improvement in the

hermaphrodite flowers as a result of foliar spray of major as well as secondary and micronutrients. Among the foliar spray of major nutrients, 0.5% H₃PO₄ spray resulted in the highest bisexual flowers (16.94%). In case of foliar spray of secondary and micronutrients 0.5% ZnSO₄ + 0.1% solubor spray recorded the highest bisexual flowers (18.1%).

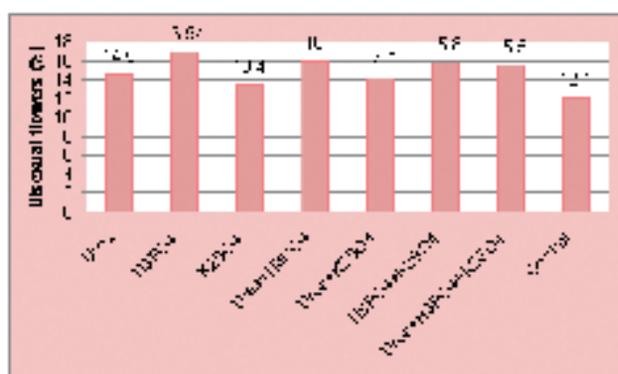


Fig. 2.3: Effect of foliar spray of major nutrients on bisexual flowers

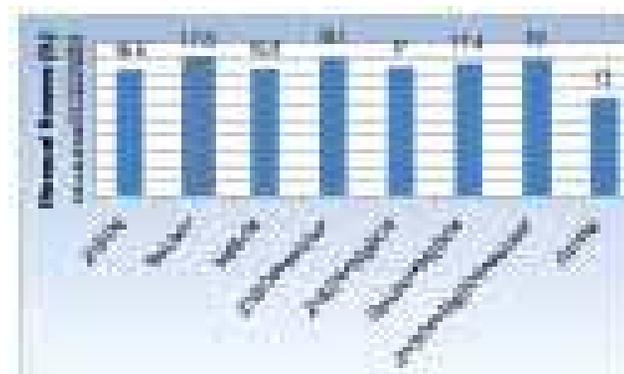


Fig. 2.4: Effect of foliar spray of secondary and micronutrients on bisexual flowers

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

A field experiment was initiated in 2009 to develop a package of recommendation for young (Expt.1: Two years old cashew variety "VRI-3") and mature (Expt. 2: Nine years old cashew variety "Bhaskara") cashew plantations involving integrated nutrient management (INM) with the application of biofertilizers, organic manures and chemical fertilizers. The experiment was laid out in a split plot design with three replications. The plants were spaced at 7m x 4m. There were four trees in each treatment. The main plots included method of biofertilizer application and the sub plots included fertilizer levels. The treatment details are given below:

(a) Main plot treatments

- i. Control (No inoculation)
- ii. Biofertilizer (*Azospirillum*, *Acetobacter*, Phosphate solubilizing bacteria and AMF 50 g each/tree) inoculation around tree basin to a radius of 45 cm.
- iii. Biofertilizer (*Azospirillum*, *Acetobacter*, Phosphate solubilizing bacteria and AMF 50 g each/tree) inoculation in the rectangular trenches taken in the middle of four trees.
- iv. Combination of ii + iii

(b) Sub plot treatments

- i. Control (No application)
- ii. 50 % of recommended NPK through drip + FYM
- iii. 75 % of recommended NPK through drip + FYM
- iv. 100 % of recommended NPK* through drip + FYM
- v. Soil test based fertiliser recommendation through drip

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

2.4.1 Profile sampling and properties of soil

The soil samples collected at three depths (0-0.30, 0.31-0.60 and 0.61-0.90 m) from base of the plant at 1.5 m radius before imposing the treatments were analysed for nutrient status. The soil was high in organic carbon, low to medium in available P and K, sufficient in available Fe, Mn and Cu and, deficient in Zn. The soil was high in organic carbon in the surface soil and decreased with increasing soil depth. A consistent decrease in the concentration of available P, K, Fe and Mn with the increase in soil depth was noted. In contrast, the available Zn increased down the profile. Copper did not show any definite trend with soil depth (Table 2.7).

Table 2.7. Properties of the experimental soil

Soil property	Soil depth (m)					
	0-0.30		0.31-0.60		0.61-0.90	
	Expt. 1	Expt. 2	Expt. 1	Expt. 2	Expt. 1	Expt. 2
Organic carbon (g/kg)	11.4	10.1	8.24	7.90	3.92	3.64
Available P (kg/ha)	20.3	18.2	16.2	15.1	14.8	13.0
Available K (kg/ha)	163.0	181.5	112.3	126.3	90.5	98.5
Available Fe (mg/kg)	120.2	108.5	89.5	81.6	60.3	56.4
Available Mn (mg/kg)	12.3	10.4	9.6	7.5	5.1	4.7
Available Zn (mg/kg)	0.39	0.31	0.50	0.45	0.59	0.57
Available Cu (mg/kg)	0.82	0.72	0.80	0.69	0.80	0.68

2.4.2 Soil moisture content

The mean monthly (January to March) soil moisture content recorded at different depths using TDR soil moisture profiling system was appreciably higher in drip irrigation plots [20.5, 20.3 and 18.2 per cent (Expt. 1) and 20.3, 18.6 and 15.7 per cent (Expt. 2) dry basis at 0.30, 0.60 and 0.90 m depths, respectively] as compared to control [11.9, 12.7 and 13.9 per cent (Expt. 1) and 11.4, 11.5 and 12.0 per cent (Expt. 2) dry basis at 0.30, 0.60 and 0.90 m depths, respectively].

2.4.3 Integrated nutrient management treatment effects on growth and yield of cashew

Method of biofertilizer application and fertilizer levels did not produce significant difference in the growth parameters of cashew (Expt. 1 and 2). The average plant height ranged from 288 to 337 cm (Expt. 1) and 750 to 900 cm (Expt. 2). The trunk girth ranged from 27.8 to 33.3 cm (Expt. 1) and 65.7 to 79.0 cm (Expt. 2). The canopy spread ranged from 312 to 352 cm (Expt.1) and 710 to 800 cm (Expt.2) (Table 2.8, 2.9).

Table 2.8: Integrated nutrient management treatment effects on growth of cashew variety, VRI-3 (Expt. 1)

Subplot treatment	Main plot treatment											
	No inoculation			Inoculation around tree basin to a radius of 45 cm			Inoculation in the middle of four trees			Combination of M2+M3		
	Plant height (cm)	Girth (cm)	Canopy spread (cm)	Plant height (cm)	Girth (cm)	Canopy spread (cm)	Plant height (cm)	Girth (cm)	Canopy spread (cm)	Plant height (cm)	Girth (cm)	Canopy spread (cm)
Control	300	28.3	306	289	27.5	325	295	29.5	316	316	31.0	327
50% NPK+FYM	297	27.9	313	310	27.8	334	290	28.7	333	304	30.3	352
75% NPK+FYM	288	28.5	334	296	27.0	322	292	29.0	325	315	29.5	320
100% NPK+FYM	331	27.8	312	324	31.1	315	321	29.4	320	298	30.3	343
Soil test based	303	27.2	319	333	29.5	330	283	29.5	332	337	33.3	340

Table 2.9: Integrated nutrient management treatment effects on growth of cashew variety, Bhaskara (Expt. 2)

Subplot treatment	Main plot treatment											
	No inoculation			Inoculation around tree basin to a radius of 45 cm			Inoculation in the middle of four trees			Combination of M2+M3		
	Plant height (cm)	Girth (cm)	Canopy spread (cm)	Plant height (cm)	Girth (cm)	Canopy spread (cm)	Plant height (cm)	Girth (cm)	Canopy spread (cm)	Plant height (cm)	Girth (cm)	Canopy spread (cm)
Control	840	72.3	717	820	70.3	742	850	67.5	713	790	70.0	717
50% NPK+FYM	820	69.3	710	780	75.2	717	750	68.2	717	820	71.2	800
75% NPK+FYM	820	70.5	783	760	70.0	775	900	69.0	725	830	67.7	750
100% NPK+FYM	780	76.7	725	790	72.3	800	810	65.7	800	810	73.3	717
Soil test based	830	73.7	792	795	79.0	783	875	70.6	713	900	70.7	742

The number of nuts produced per tree and nut yield (kg) per tree was found to be significantly increased due to biofertilizer and different levels of fertilizer application. Among the method of biofertilizer application tested, application of biofertilizer (*Azospirillum*, *Acetobacter*, Phosphate solubilizing bacteria and AMF) inoculation 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) was found to be effective. Highest nut yield (1.4 and 8.1 kg/tree in Expt. 1 and 2, respectively) was obtained in treatment receiving 100 % of recommended NPK through drip + FYM. The fertilizer levels 75% recommended NPK through drip + FYM and soil test based fertiliser recommendation through drip were at par but significantly superior over control (Table 2.10, 2.11).

Table 2.10: Integrated nutrient management treatment effects on nut yield (kg/tree) of cashew variety, VRI-3 (Expt. 1)

Subplot treatment	Main plot treatments			
	No inoculation	Inoculation around tree basin to a radius of 45 cm	Inoculation in the middle of four trees	Combination of M2+M3
Control	0.98	1.00	1.18	1.16
50% NPK+FYM	0.99	0.98	1.15	1.21
75% NPK+FYM	1.10	1.20	1.34	1.38
100% NPK+FYM	1.30	1.34	1.25	1.40
Soil test based	1.25	1.30	1.29	1.31
CD (5%) Main plot = 0.179, Sub plot = 0.134, Main x sub = 0.297				

Table 2.11: Integrated nutrient management treatment effects on nut yield (kg/tree) of cashew variety, Bhaskara (Expt. 2)

Subplot treatment	Main plot treatments			
	No inoculation	Inoculation around tree basin to a radius of 45 cm	Inoculation in the middle of four trees	Combination of M2+M3
Control	7.1	7.2	6.8	7.5
50% NPK+FYM	6.8	7.1	7.0	7.4
75% NPK+FYM	7.0	7.6	7.3	7.9
100% NPK+FYM	7.4	7.6	8.0	8.1
Soil test based	7.2	7.4	7.5	7.7
CD (5%) Main plot = 0.382, Sub plot = 0.602, Main x sub = 1.05				

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

2.5.1 Nursery trial

Cashew seedlings and grafts required for field studies were raised in the nursery with and without biofertilizer inoculation. Cashew seeds of "Bhaskara" variety were sown with and without biofertilizers and combination of biofertilizers and chemical fertilizers in the poly bag containing the potting mixture (1:2:3-FYM: Sand: Soil). Microbial inoculants including *Azospirillum* (5g), *Pseudomonas* (5g), AMF (2.5g), and P-solubilizer (5g) were applied together as band, 3-5cm below the seed and covered with soil, above which seeds were sown as stalk end upwards.

In another batch, when seedlings were two months old, scion of "Bhaskara" variety was grafted on seedlings and maintained for another one month. The grafts were treated with different biofertilizers and combination of biofertilizers and chemical fertilizers as per the treatment details furnished below:

Treatments:

T1- Control

T2- Biofertilizer consortium (BFC)*

T3- BFC alone

T4- 50 % NPK + BFC

T5- 100%NPK + BFC

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

There were 50 plants in each treatment. Potting mixture samples were collected before imposing the treatments for their nutrient content, microbial population and enzyme activity. Observations on growth of both seedlings and grafts were taken during 3.5 months after sowing and 1.5 months after grafting, respectively (Table 2.12).

2.5.1.1 Effect of treatments on biometric parameters and nutrient content of cashew under nursery trial

The treatment BFC alone significantly increased the plant height, stem girth, stem dry weight, leaf dry weight, root dry weight and total biomass. However, treatments did not affect the number of leaves and leaf area (Table 2.13, 2.14). In case of grafts, higher plant height and stem girth were obtained by the application of 100% NPK fertilizers+BFC (T4). The treatment 50% NPK + BFC (T5) recorded the highest number of leaves/plant (Table 2.15). Among all the treatments, BFC only (T3) showed higher nutrient content of N, P and K in leaf. The treatment 50%NPK + BFC (T5) showed appreciably higher concentration of P in root than other treatments (Table 2.16).

Table 2.12: Pre-treatment nutrient status, microbial population and enzyme activity of the potting medium under nursery trial

Nutrient status	
OC (%)	1.10
P (ppm)	163.8
K (ppm)	188.2
Ca (ppm)	994.8
Mg (ppm)	161.1
Cu (ppm)	7.4
Zn (ppm)	11.6
Fe (ppm)	110.1
Mn (ppm)	32.4
Microbial population	
Bacteria x 10 ⁵	83.4
Fungi x 10 ⁴	38.1
<i>Actinomyces</i> x 10 ⁵	38.1
N-fixers x 10 ⁴	3.6
P-solubilizers x 10 ⁵	11.5
Enzyme activity	
Dehydrogenase activity (μ gTPF/g dry soil/24h)	15.8

Table 2.13: Effect of treatments on biometric parameters of cashew seedlings under nursery trial

Treatment	Plant height (cm)	Stem girth (cm)	No. of leaves	Leaf area(cm ²)
T1- Control	35.5	3.35	16.0	45.1
T2- 100% NPK	30.0	3.05	17.5	45.2
T3- BFC only	41.3	4.00	28.0	65.9
T4- 100% NPK+BFC	33.8	3.50	17.5	48.5
T5- 50%NPK + BFC	32.9	3.65	16.5	61.6
CD (5%)	3.99	0.164	ns	ns

Table 2.14: Effect of treatments on dry weight of different parts of cashew seedlings under nursery trial (g)

Treatment	Stem	Leaf	Root	Total biomass
T1- Control	3.14	3.85	1.59	8.58
T2- 100% NPK	1.95	2.61	0.84	5.40
T3- BFC only	4.66	6.26	2.59	13.5
T4- 100% NPK+BFC	3.37	3.98	2.00	9.4
T5- 50%NPK + BFC	3.51	4.38	2.43	10.3
CD (5%)	1.45	0.79	1.69	1.88

Table 2.15: Effect of treatments on biometric parameters of cashew grafts under nursery trial

Treatment	Plant height (cm)	Stem girth (cm)	No. of leaves
T1- Control	25.8	2.26	5.4
T2- 100% NPK	30.6	2.78	8.4
T3- BFC only	31.8	2.82	8.8
T4- 100% NPK+BFC	35.0	3.24	8.6
T5- 50%NPK + BFC	33.4	3.18	9.0

Table 2.16: Effect of treatments on nutrient content of seedlings in nursery (%).

Treatment	N		P		K
	Leaf	Leaf	Root	Leaf	
T1- Control	1.35	0.20	0.28	0.45	
T2- 100% NPK	1.37	0.15	0.23	0.45	
T3- BFC only	1.54	0.31	0.39	0.60	
T4- 100% NPK+BFC	1.39	0.20	0.21	0.32	
T5- 50%NPK + BFC	1.47	0.27	0.43	0.56	
CD(5%)	0.029	0.054	0.069	0.017	



Effect of treatments on root system of seedlings under nursery trial

2.5.2 Field trial

Cashew grafts and seedlings of "Bhaskara" variety raised in the nursery with different treatments as explained under nursery trial were transplanted into the field. Different biofertilizers and inorganic fertilizers as described below were applied to newly planted cashew grafts and seedlings.

Treatments:

T1-Control

T2- *100% NPK

T3-25% NP + 100% K + **BFC

T4-50% NP + 100% K + BFC

T5-75% NP + 100% K + BFC

T6-100% NPK + BFC

T7-BFC alone.

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

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

The experiment was laid out in RBD with three replications. There were six grafts and four seedlings in each treatment. Five kg cattle manure/plant was applied uniformly to all the plants. The plants were spaced at 5m x 5m.

2.5.2.1 Effect of treatments on growth observations under field trial

Growth observations of both seedlings and grafts were recorded after 4 and 7 months after planting.

a) Grafts: All treatments increased significantly the plant height of cashew grafts at 4 and 7 months after planting, compared to the untreated plants (Table 2.17). Among the different treatments, 50% NP+100% K + BFC (T4) showed the highest plant height. Similar to plant height, the highest stem girth was shown by the treatment 50% NP+100% K + BFC (T4). All the treatments were significantly increased the stem girth compared to untreated plants. The treatment 50% NP+100% K + BFC (T4) significantly increased the number of leaves followed by the treatments 25% NP+100% K + BFC (T3) and 75% NP+100% K + BFC (T5) which were on par with each other. All the treatments recorded higher canopy spread than untreated plants.

Table 2.17: Effect of treatments on growth observations of cashew grafts under field trial

Treatment	Plant height(cm)		Stem girth(cm)		Total no. of leaves (4MAP)	Leaf area(m ²) (4MAP)	Canopy spread (cm) (7MAP)
	4 MAP*	7MAP	4MAP	7MAP			
T1-Control	72.17	104.17	4.43	6.50	46.67	33.55	60.58
T2-100% NPK	93.67	144.17	5.28	8.08	80.67	100.97	81.67
T3-25% NP+100% K+BFC	93.50	139.83	5.30	7.80	111.67	143.02	78.42
T4-50%NP+100% K +BFC	102.50	170.00	5.83	8.78	112.00	150.27	88.08
T5-75% NP+100% K+BFC	90.67	140.00	5.57	8.75	108.00	131.37	87.25
T6-100%NPK+BFC	93.00	152.83	5.28	7.97	89.33	122.13	82.92
T7-BFC Only	89.50	140.83	5.08	7.52	66.00	73.38	79.75
CD(5%)	8.02	18.98	0.32	0.88	37.49	55.75	12.92

*MAP = Months after planting

b) **Seedlings:** The treatment 50% NP+100% K + BFC (T4) showed higher plant height at four months after planting followed by 100% NPK (T2) and 25% NP + 100% K + BEC (T3) (Table 2.18). The trend was not similar at 7 months after planting in which 25% NP + 100% K + BFC (T3) showed the highest plant growth followed by BFC (T7). The treatment 75% NP + 100% K + BFC (T5) significantly increased the stem girth at 4 months after planting but at 7 months after planting different treatments did not affect the stem girth. Similar to stem girth, number of leaves and leaf area were significantly higher in 75% NP+100% K + BFC (T5). All the treatments increased the canopy spread significantly compared to control.

2.6 Rootstock studies in cashew

The different stionic combinations planted in the field were compared for various growth parameters. Except for number of leaves per shoot and bark percentage the different growth parameters did not vary significantly among different stionic combinations in the first year of observation. The variety VRI-3 on Brazil dwarf rootstock recorded the highest number (17.16) of leaves per shoot, while V-4 on Taliparamba-1 rootstock recorded the least (9.33) number of leaves per shoot. The bark percentage was highest (64.28%) when Ullal-3 was grafted on V-4 rootstock, while it was least (40.68%) when VRI-3 was grafted on V-4 rootstock (Table 2.19).

Table 2.18: Effect of treatments on growth observations of cashew seedlings under field trial

Treatment	Plant height(cm)		Stem girth(cm)		Total no. of leaves	Leaf area (m ²)	Canopy spread (cm)
	4 MAP	7 MAP	4 MAP	7 MAP	(4 MAP)	(4 MAP)	(7 MAP)
T1-Control	86.17	129.33	4.98	7.12	58.33	36.42	64.58
T2-100% NPK	109.17	155.83	5.53	7.70	92.67	97.77	83.75
T3-25% NP+100% K+BFC	109.17	172.50	5.67	7.80	66.67	77.11	82.50
T4-50% NP + 100% K +BFC	112.83	153.33	5.60	7.73	79.50	81.86	81.25
T5-75% NP + 100% K +BFC	98.50	154.00	5.67	8.17	97.33	100.31	79.58
T6-100% NPK + BFC	87.33	157.00	5.57	7.68	73.83	64.89	81.50
T7-BFC Only	98.50	161.67	5.63	7.80	86.67	78.93	77.50
CD(0.05)	18.16	25.44	0.63	ns	25.69	38.93	11.96

Table 2.19: Growth parameters in different stionic combinations in cashew

Stionic combination (scion/stock)	Plant height (cm)	No. of leaves per shoot	No. of shoots	Girth below union (cm)	Girth above union (cm)	Inter nodal length (cm)	Canopy spread (cm)	Bark (%)
Ullal-3/ V-4	193.33	10.49	40.44	12.55	10.80	3.17	129.22	64.28
VRI-3/V-4	190.27	15.11	29.94	11.28	9.50	2.67	111.77	40.68
NRCC Sel-2/V-4	162.50	13.61	37.42	11.30	9.94	2.95	144.14	51.39
V-4/V-4	181.66	13.83	24.33	12.16	10.83	2.73	105.77	59.75
Ullal-3/ Brazil dwarf	208.33	12.28	45.40	13.50	12.23	3.24	145.86	44.82
VRI-3/ Brazil dwarf	206.66	17.16	39.16	12.66	10.99	2.72	155.00	55.92
NRCC Sel-2/ Brazil dwarf	137.55	13.66	49.54	10.14	8.97	3.01	178.25	57.65
V-4/ Brazil dwarf	180.27	12.42	23.07	12.03	9.79	2.59	95.42	60.17
Ullal-3/ Taliparamba-1	160.41	10.41	28.49	12.08	7.61	3.22	116.24	52.72
VRI-3/ Taliparamba-1	156.87	14.60	26.57	11.75	10.27	2.71	97.35	54.56
NRCC Sel-2/ Taliparamba-1	143.75	11.00	19.00	8.25	6.75	3.25	72.25	53.16
V-4/ Taliparamba-1	169.33	9.33	15.00	9.66	7.66	2.87	76.00	49.95
CD (5%)	NS	4.22	NS	NS	NS	NS	NS	5.33



3. CROP PROTECTION

3.1 Cashew Stem and Root Borers (CSRB)

3.1.1 Standardization of composition of semi-synthetic diet (SSD) to enhance feed utilization and survival to adults

Use of cashew bark powder or saw dust as base constituent led to fast drying and lower consumption of SSD. Pulverised paddy straw was incorporated in the SSD to enhance the moisture retention of SSD. This enhanced the duration of palatable moisture level (condition of SSD during which a blunt edged tool could be effortlessly thrust into the SSD) to 44 to 61 days in the paddy straw based diet from the former duration of 18 to 28 days in case of saw dust based SSD and 22-35 days in case of SSD based on cashew bark powder. The percentage of SSD consumption was maximum in case of pulverised paddy straw based SSD (72.92) while, it was minimum

in case of saw dust based SSD (43.25) (Table 3.1).

The CSRB grubs were reared individually in glass rearing bottles provided with the SSD having either cashew bark powder, saw dust, pulverised paddy straw as well as cashew bark as control. The mean weight of CSRB grubs at various age groups was obtained by random sampling for recording the body weight as well as percentage of SSD consumed during each feed change.

The mean weight of CSRB grubs was highest in all the age groups when natural bark was provided as feed, followed by the grubs which were reared on SSD having pulverised paddy straw. The CSRB grubs reared on SSD having base composition of cashew bark powder had higher body weight in comparison to those reared on saw dust based diet (Fig.3.1).

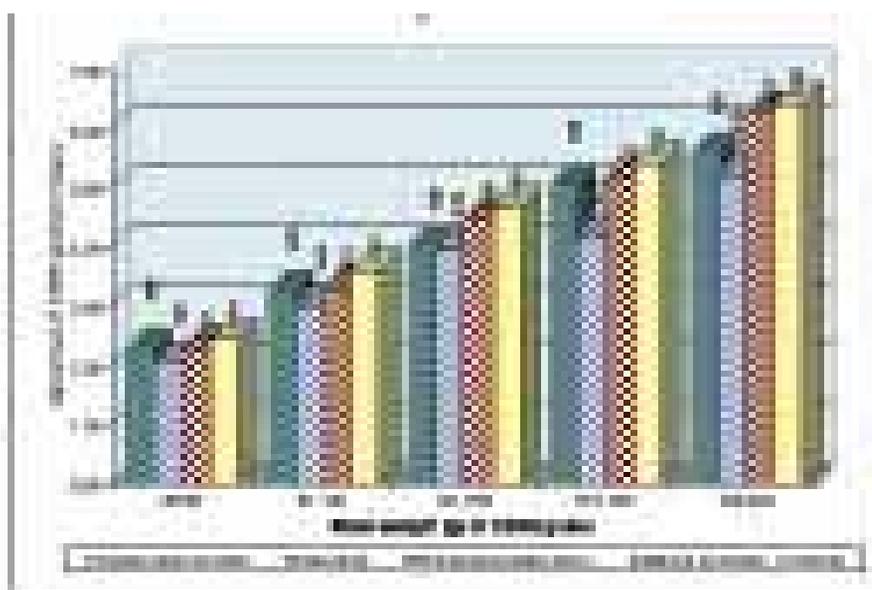


Fig.3.1: Mean weight (g) of CSRB grub stages when reared on various composition of SSD

Table. 3.1: Effect off different constituents of SSD on development of CSRB grubs

Base material used for preparation of SSD	Mean weight of CSRB grubs (g) (120 - 180 days)	Duration of palatable moisture in SSD (days)	Mean % of SSD consumed
Saw dust	3.210	18-28	43.25
Cashew bark powder	3.725	22-35	47.16
Pulverised paddy straw	4.325	44-61	72.92
Cashew bark alone	4.638	—	—

The number of grubs surviving in each age group was recorded in all the four treatments. It was noticed that the survival percentage of CSRB grubs was the lowest (44.0) during the 45 - 90 days age group and gradually increased with the increase in age (53.3 to 76.0 %) in all the compositions of SSD. The pupal formation was very meagre (19.4 per cent to 24.0 per cent) due to incomplete cocoon formation. Addition of calcium carbonate or calcium hydroxide (0.5%) could enhance the formation of calcareous cocoons (Table 3.2).

During the current year, for the first time, 11 adult beetles of CSRB (5 male beetles and 6 female beetles) could be obtained by rearing the insect from nascent grub stage to pupation only on the SSD; which was totally constituted of ingredients other than the natural host material (cashew bark). This SSD composition

needs further alteration for enhancing complete pupal cocoon formation, which was one of the main constraints in development of pre-pupa to adult.

3.2 Studies on insect fauna associated with stored cashew nuts / kernels

3.2.1 Estimation of damage by *Ephestia cautella* and *Tribolium castaneum* on stored cashew kernels

It was noticed that the larvae of *E. cautella* caused less than 0.5 per cent weight loss in 15 days while it was 1.0 to 1.5 per cent weight loss in 30 days after release of larvae. The weight loss was 5 - 8 per cent at 45 days and 10 to 12 per cent at 60 days after release of larvae. The infestation pattern was observed to be evenly distributed in the stored container in case of *E.cautella* while, *T. castaneum* occupied the lower portions of the stored kernels (Table 3.3).

Table 3.2: Mean survival percentage of CSRB grub stages when reared on various compositions of SSD

Age group of CSRB grubs (days)	Base material used for preparation of SSD			
	Cashew bark powder	Saw dust	Pulverised paddy straw	Natural host bark (Control)
45-90	44.0	40.0	45.4	46.2
91-120	57.4	51.0	68.6	66.6
121-150	53.3	55.7	72.0	68.1
151-180	64.9	52.5	88.0	81.8
180-240	76.0	78.9	78.0	74.2
Pupa	19.4	18.5	22.0	24.0

Table 3.3: Weight loss due to *Ephestia cautella* infestation in cashew kernel at different intervals after incidence

	% Loss of weight in the sample after			
	15 days	30 days	45 days	60 days
Batch I	0.27	0.91	5.63	10.40
Batch II	0.34	1.01	6.95	9.85
Batch III	0.29	1.19	6.33	10.80

It was noticed that the *Tribolium* adults preferred to feed on the embryo (germ) and scraping the external portion but could not burrow into the kernel. The weight loss due to the infestation was less than 1 per cent even at 30 days after release of the pest, between 1.0 to 1.5 per cent during 45 days and was 1.5 to 2.5 per cent at 60 days after release of the storage pests into the kernel (Table 3.4).

3.3 Studies on the determination of insecticide residues in cashew apples

The cashew apple samples collected at regular intervals from the trees treated with carbaryl (0.2%) during cashew apple development stage were analyzed for the residues of the insecticide for studying the pattern of degradation. The residues level fell below the Maximum Residue Limit (MRL) of 0.5 ppm within two weeks of treatment.

Similarly, samples collected at regular intervals from the trees treated with λ -cyhalothrin (0.003%) were got analyzed for studying the degradation pattern. The level of residues of carbaryl fell below the Maximum Residue Limit (MRL) of 0.2 ppm within 15 days of treatment.

3.4 Tea Mosquito Bug (TMB)

3.4.1 Biosystematics TMB

Biotechnological tools were employed to assess taxonomic relation between different species of TMB viz., *Helopeltis antonii*, *H. theivora* and *Pachypeltis maesarum*. The study was also aimed at finding out the relationship between the samples of *Helopeltis antonii* collected from different cashew growing areas of the country. The details of the samples used for the study are given in Table 3.5.

Table 3.4: Weight loss due to *Tribolium castaneum* infestation in cashew kernel at different intervals after incidence

	% Loss of weight in the sample after		
	30 days	45 days	60 days
Batch I	0.41	1.44	1.51
Batch II	0.35	1.05	2.18
Batch III	0.62	1.20	1.92

Table 3.5: Details of the samples of TMB collected from different parts of India

DCR-2	<i>Helopeltis antonii</i> collected during November 2009 from Kemminje campus of DCR,Puttur .
DCR-3	<i>Pachypeltis maesarum</i> collected from Kemminje campus of DCR,Puttur.
DCR-4	<i>Helopeltis antonii</i> collected from Regional Agricultural Research Station, Pelicode, Kerala.
DCR-5	<i>Helopeltis antonii</i> collected from Cashew Research Station, Madakkathara, Kerala.
DCR-6	<i>Helopeltis antonii</i> collected from Agriculture Research Station, Chintamani, Karnataka.
DCR-7	<i>Helopeltis antonii</i> collected from Agricultural Experimental Station, Paria Gujarat.
DCR-8	<i>Helopeltis antonii</i> collected during December 2009 from Regional Fruit Research Station (RFRS), Vengurle, Maharashtra from the inorganic cashew plantation.
DCR-9	<i>Helopeltis antonii</i> collected during December 2009 from Regional Fruit Research Station (RFRS), Vengurle, Maharashtra from the organic cashew plantation.
DCR-10	<i>Helopeltis antonii</i> collected from Central Plantation Crops Research Institute (CPCRI), Vittal, Karnataka from cocoa plants grown as intercrop with arecanut.
DCR-11	<i>Helopeltis antonii</i> collected from IIHR, Bangalore from guava plants .
DCR-12	<i>Helopeltis antonii</i> collected from Agriculture Research Station, Chintamani, Karnataka from neem tree.
DCR-13	<i>Helopeltis theivora</i> collected from Payyanur, Kerala from <i>Acalypha hispida</i> plant.

The genomic DNA was extracted from all the samples using C- Tab method. The amplified DNA was eluted from the agarose gel for ligation and transformation. 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 with 'Fermentas kit'. The plasmid purity was assessed by gel electrophoresis. Sequencing of the extracted plasmid revealed changes in the nucleotide base between the samples. The variation between the samples of *Helopeltis antonii* collected from different location was not significant, while, the difference between different species was highly significant.

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, VTH30/4 ,VTH174,VRI-3, Vengurle -1,Vengurle-3, Vengurle-4,Dhana, Kanaka, Priyanka, Madakkathara-2, K22-1, NRCC-Selection-1, Madakkathara -1, H32-4, Ullal-4, Vengurle n7 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 = more than 6 coalescing lesions

and 4 = complete drying) during flushing/flowering/ fruiting periods (Fig. 3.2).

The incidence of TMB was lower in Dhana and the damage score ranged from 0.03-1.17. This was followed by Bhaskara (0.0-1.55), VRI-3(0.03-1.57) and Ullal-1(0.00-1.60). The incidence was maximum in NRCC Selection-2 with maximum damage score of 3.07 recorded during first fortnight of March 2010.

3.4.3 Incidence of TMB in the trees with foliar treatment of micronutrients

3.4.3.1 Foliar application of nutrient spray - TMB incidence

The nutrient sprays namely : 1. Urea, 2. H₃PO₄ (0.5%),3. K₂SO₄ (1%),4. Urea 3% + H₃PO₄ (0.5%),5. Urea 3% + K₂SO₄ (1%),6. H₃PO₄ (0.5%) + K₂SO₄ (1%),7. Urea (3%) + H₃PO₄ (0.5%) + K₂SO₄ (1%)and 8. Control were given thrice at flushing/fruiting and flowering 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 K₂SO₄ (1%)sprayed plots and the damage score ranged from 0.14-1.54. This was followed by Urea 3% + H₃PO₄ (0.5%) in which the damage score ranged from 0.16 to 2.09. In all the other treatments the damage rating was higher (Fig.3.3)

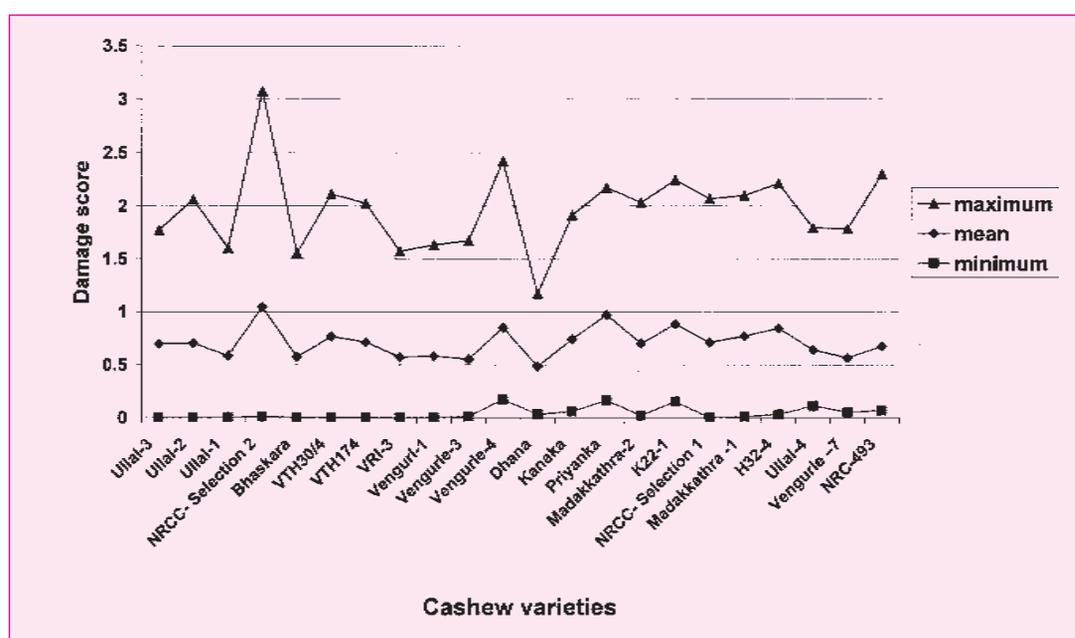


Fig.3.2: Reaction of released varieties/accessions to Tea Mosquito Bug

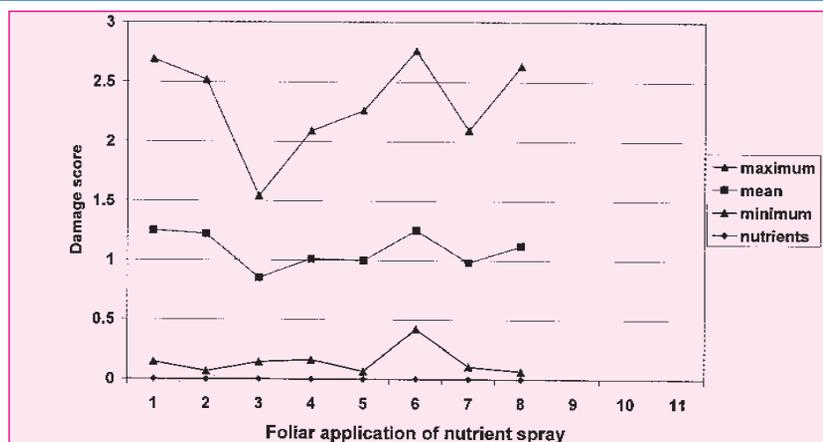


Fig.3.3: Reaction of "NRCC Sel-2" treated with major nutrient spray to TMB

3.4.3.2 Foliar spray of secondary and micronutrients - TMB incidence

Foliar spray of secondary and micronutrients viz., 1. ZnSO₄ (0.5%), 2. Solubor (0.1%), 3. MgSO₄ (0.5%), 4. ZnSO₄ (0.5%) + Solubor (0.1%), 5. ZnSO₄ (0.5%) + MgSO₄ (0.5%), 6 Solubor (0.1%) + MgSO₄ (0.5%), 7. ZnSO₄ (0.5%) + Solubor (0.1%) + MgSO₄ (0.5%) and 8. Control were given thrice at flushing/fruiting and

flowering 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 and the damage score ranged from 0.06-1.60. This was followed by MgSO₄ (0.5%) in which the damage score ranged from 0.14 to 1.64. In untreated control the incidence of TMB was higher with a maximum of 2.85 (Fig.3.4).

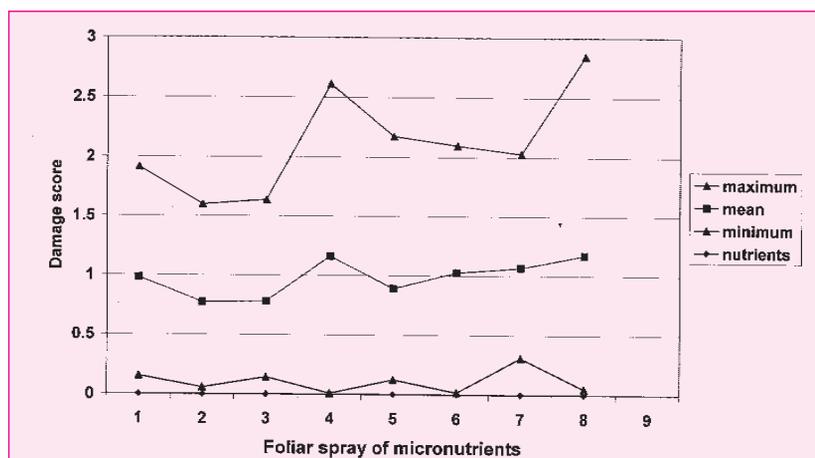


Fig.3.4: Reaction of NRCC Sel-2 cashew variety treated with micronutrients to TMB

3.4.4 Evaluation of fenpropathrin against tea mosquito bug (TMB) under field condition.

Fenpropathrin (Meothrin 30 EC) supplied by M/S Sumitomo Chemical (India), Mumbai was evaluated against TMB under field condition in larger plots. Sprays were given at flowering and fruiting stages. Damage on shoots was assessed after one month of second spray on 0 - 4 scale. The damage grade was recorded in 52 shoots in each tree and mean damage was worked out. The damage rating (0.52) in fenpropathrin (0.02%) was on par (0.42) with the recommended insecticide λ- cyhalothrin (0.003%). In untreated check, the damage rating was 1.23. There was no significant difference in the natural enemy complex in the treated plots and untreated control. The benefit :

cost ratio for fenpropathrin (0.02%) was 1.78:1 compared to 2.17:1 for λ cyhalothrin (0.003%).

3.5 Evaluation of synthetic fungicides against flower drying disease of cashew

Spraying of mancozeb, carbendazim, copper oxychloride and propiconazole was taken up during flowering period on cashew variety "NRCC Selection - 2" in which occurrence of flower drying disease is very common. The unopened flowers due to the disease incidence were estimated one month after second and final spray. The incidence of disease was lower in mancozeb (8.9%) treated trees followed by copper oxychloride(11.9%) and propiconazole (14.6%). The damage rating in untreated control was 22.8 per cent.

4. POST-HARVEST TECHNOLOGY

4.1 Design and development of dryer for raw cashewnuts

Trials were conducted using the dryer available in Kudal, Maharashtra to dry raw cashewnut. This dryer is operated by thermal power generated from wooden logs and consists of hot air generation and drying chamber. Heat content of burning wooden logs are transferred to air stream by conduction process and forced into drying chamber. A blower is connected between outlet of drying chamber and inlet of heat generating system to circulate hot air inside drying and heat generating chamber. Fans provided inside the drying chamber ensured uniform drying in the chamber. Temperature sensor provided in the circuit cut off the power supply to the blower immediately after attaining the set temperature. Resolution of the trials were conducted using the dryer available in Kudal, Maharashtra to dry raw cashewnuts. After confirming 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, time required for stabilization of hot air, 100 kg of soaked (8 h) raw cashewnuts loaded in thin layers. It was found that the dryer required minimum of 1 to 1.5 h. to stabilize air temperature inside drying chamber. Dryer maintained at temperature of 70°C required minimum 6 h to reduce the moisture content below 8% (d.b)

4.2 Studies on alternate energy utilization of cashew shell cake

Four different type of briquetting machines viz., screw type extruder, ram type briquette making machine (60 mm ϕ), ram type briquette making machine (90 mm ϕ) and roller press available at M/s Sree Engineering Co., Hyderabad were used. Pulverized cashew shell cake and saw dust were mixed in the ratio of 30:70 and 50:50 and fed into the screw extruder. Briquette could be formed with 30:70 ratio, but due to the presence of heating element in the densification zone, fumes generated. In the case of ram type briquette making machine (60 mm ϕ) due to high impact force applied i.e. 1200 kg cm⁻², briquette were formed, but

cracks developed at disc joint (width of the disc depends on stroke length of ram) reducing the stability of briquette. As the torque generated in the 90 mm ϕ size ram type briquette making machine was higher, briquettes could be formed but superior end product in terms of stability. Carbonized briquette could be made out of the carbonized material using roller press, indicating that cashew shell cake obtained from drum roasting process (partially burnt shell) can be carbonized completely by retort process and converted in to carbonized briquette for value addition to cashew by-product.

4.3 Development of compact type drum roasting machine for raw cashewnuts

A conceptual design of mechanized roasting unit consisting of feeding, roasting and cooling zones is prepared. Considering physical dimensions of raw cashewnut (bulk density and spericity), material of construction (mild steel), heat source (LPG), roasting temperature (~600°C), feed rate, rotational movement in relation to movement of raw cashewnut inside the drum and influence of slope of the drum, design of the continuous feed compact roasting machine for raw cashewnuts was refined.

Experiments were conducted by exposing the raw cashewnuts to temperature ranging from 150°C to 600°C at an interval of 50°C in a muffle furnace. Experiments were limited to muffle furnace inner chamber temperature of 600°C, in view of characteristics of mild steel of 6mm thickness reaching red hot condition at this temperature level. Minimum temperature needed for raw cashewnut having moisture approximately 5% on d.b exposed to a temperature of 400°C required residential time of 143 seconds. Further experiments at higher temperature revealed that residential time required to burn raw nut decreased with increased temperature. Later on, unpeeled kernels extracted from cracking burnt nuts obtained from nuts exposed to different temperature were manually peeled and its surface colour values in terms of luminance of a colour (L), hue (a), saturation (b) using hunter colour

flex meter were found out. Whiteness and yellowness index representing quality of kernel were worked out.

4.4 Value chain on cashew for domestic and export market (NAIP)

Certain physical properties of raw cashewnuts of released varieties and imported nuts have been initiated to determine axial dimension, porosity, bulk density and true density. In consultation with cashew processors, traders and farming community various standards being followed to assess quality of raw cashewnuts have been listed i.e. number of nuts per unit weight, cutting test (% of good kernels), size of the nuts, moisture content of nuts (rattling sound), extraneous matter, void nuts, broken and damaged nuts and floating test (to find out spoiled and improperly filled nuts).

A conceptual design of motorized concentric type rotary sieve grader is developed. This unit consists of feed hopper, feed control mechanism, concentric rotary sieve drums and a drive mechanism. Feed hopper could be 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) and pressing nuts with the help of wheels aligning the sieve whole provided throughout the length of the sieve drum. Hopper bottom would facilitate in collecting the graded nuts just below each concentric rotary drum. A 2hp

electrically powered 3 phase (50 cycles/sec) motor is recommended to operate the whole unit.

Variation curve for the minor axis dimension of raw cashewnut revealed that the width of the nut ranges from 18.32 to 29.79 mm. The proportion of nuts in a given mass showed that small (<20.0mm), medium (20.1-22.0mm) and big (>22.1mm) size nuts are in the ratio of 10:70:20. Also, the effective width of the nut was used as criteria to size grade the raw cashewnuts. Therefore, circular c/s sieves of size of 20 mm ϕ , 22 mm ϕ and 24 mm ϕ are selected.

Assuming the maximum thickness of the nut in its natural resting position as 20 mm, the arc length of entering nut mass in single layer making approximately 66° angle with centre of the sieve cylinder (45 cm ϕ) is $2\pi r\phi/360$ i.e. 22.53 cm. The ratio between number of sieve holes available per unit length and the nuts entry implies that individual nuts gets around 17 times opportunity to register the sieve holes. Therefore, inner cylinder of 45 cm ϕ is sufficient enough to grade the initial mass of the nuts. The annular space between sieve cylinders was selected as 15 mm to ease the passage of under-size nuts in to the next sieve cylinder. Considering the strength of mild steel perforated sheet with zig zag sieve holes (18-gauge) and total sieve area, the spacing between sieve holes of the rotary cylinders were selected as 6 mm, 7mm and 8 mm for inner (45 cm ϕ), middle (65 cm ϕ) and outer (75 cm ϕ) respectively.



5. TRANSFER OF TECHNOLOGY

5.1 Training programme

During the year a training programme on "Softwood Grafting and Nursery Management in Cashew" was organized for the officials of Shree Kshethra Dharmasthala Rural Development (SKDRDP), Dharmasthala.

A training programme on "Cashew and Composting of Recyclable Cashew Biomass" was organized for the 16 officials of BAIF (DRUVA unit of Gujarat and MITTRA unit of Maharashtra during 16-18 December, 2009).

A training programme on "Cashew Production Technology" was organized for 25 farmers and Horticultural Officers of Andhra Pradesh during 2-4 December, 2009.

A refresher course on "Cashew Production Technology" was organized during 20-22 January, 2010 for 14 participants from BAIF (DRUVA unit, Gujarat); 2 participants from Orissa State Forest Department and 2 participants from Department of Agriculture, Govt. of Assam.

Four training programme on 'Cashew Processing' was conducted at Post Harvest Technology section benefiting 75 Women from Kerala State belonging to Kudumbashree, Kasaragod and Agricultural Technology Management Agency (ATMA), Kannur.

5.2 Participation in Exhibition

- State Youth Festival "Yuvajana Mela-2009" : 26-28 December, 2009 - Sullia, Karnataka State Department.
- Mass media and communication programme of NAIP project: 8-12 February, 2010 - Peruvannamali, IISR, Calicut.
- Flower and fruit show : 19-23 February, 2010 - Karnataka State Department of Horticulture, Mangalore.
- National Conference on Production of Quality Seeds and Planting material - Health Management in Horticultural Crops : 11-14 the March 2010, - Horti Expo organized at NASC Complex, New Delhi.

- NAIP Sub - Project on Mobilising Mass Media Support for Sharing Agro Information : 26-27 March 2010, - Indian Institute of Horticultural Research, Bangalore.

5.3 Consultancy / Advisory visits

A team of four scientists participated in National Seminar cum Workshop on Hilly land Development with Special Reference to Cashew, organized at Diglipur in North Andaman during 18-20 November, 2009. They delivered lectures, made field visits and offered technical advice during the Workshop.

A team of two scientists visited the cashew orchards established by tribal farmers with guidance from BAIF, Pune (DRUVA in Gujarat and Dadra Nagar Haveli Union Territory and MITTRA in Maharashtra). They studied the situation and conditions of cashew orchards in Dang, Navsari and Valsad Districts of South Gujarat, Part of Dadra Nagar Haveli Union Territory and Nasik and Thane Districts of Maharashtra and offered consultancy for the improvement of cashew orchards and the production.

Scientists visited cashew orchards established by farmers in association with the NGO and a KVK in Shimoga and offered technical guidance. Scientists also participated in the training programme by giving lectures on cashew production technology and planting material generation and nursery management in cashew. A group of scientists participated in the cashew day programme of HRS, Ullal and delivered lecture on Cashew Production Technology specially on varieties and canopy management in cashew.

5.4 Study visit of farmers

A batch of seven progressive cashew farmers were taken to Bhubaneswar to participate in National Seminar on Cashew organized by DCCD, Kochi. The team visited cashew orchards and industries during the visit.

5.5 Visitors

About 16 batches of farmers, students and other visitors to the institute were taken to various experimental plots, cashew museum and laboratories and were explained about cashew cultivation practices and research findings of this Directorate. Besides, several individual visitors and visitors in small batches were also attended by giving required information.

5.6 Cashew Day

"Annual Cashew Day 2010" was organized on 4th March, 2010 at Keyyur village in Puttur taluk. The programme was organized in association with the Cashew Demonstration farmers of the village. About 300 farmers participated in the programme. The visitors were taken to demonstration Plots and were shown the beneficial effect of inputs in cashew. An exhibition on Production Technology of cashew was also organised. In the group discussion organized on the occasion progressive farmers were given opportunity to speak.



Discussion with Director, DCCD, Kochi

The officials of Development Departments also briefed about the opportunities and support available to the cashew farmers.

5.7 Demonstrations

During the year three new demonstration plots on high density planting of different high yielding cashew varieties were laid out in Puttur and Buntwal taluks. Farmers were offered technical advice on planting and establishment of demonstration plots. Financial assistance from DCCD, Kochi was also made available to these farmers. Already existing demonstration plots which have completed more than four years were also monitored by making frequent advisory visit and offering technical guidance.

5.8 Cashew database

Compared to a manual database, a computerized database is more flexible, compact, and faster. It reduces the probability of inconsistent data. When a database is teamed with a computer, many of the problems with a manual database are eliminated. The advantages of

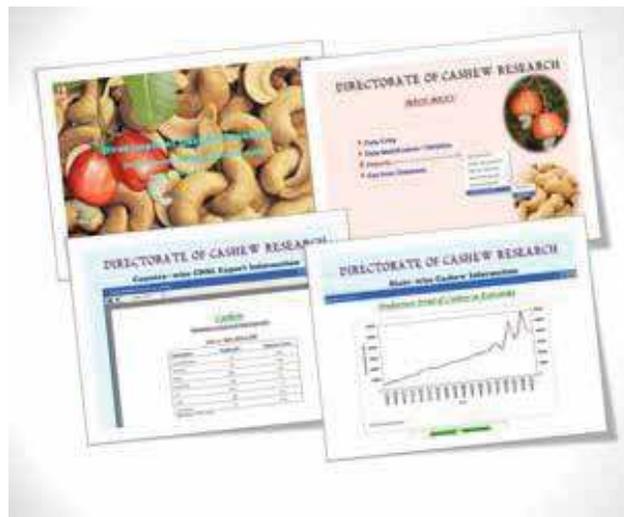
computerized database over manual database are as follows :

Speed: It can find a specific record or information from among thousands or even a million entries within a second.

Compact: The database records stored in filing cabinets can be stored in a single compact disk.

Flexible: It has the ability to examine information from a number of ways.

A cashew database is a software program, used to store, delete, update and retrieve cashew information on various aspects like different countries and domestic area under cashew, production, productivity, export and import of cashew raw nuts, cashew kernels and cashew nut shell liquid. The output of the selected data will be displayed in both numerical and graphical formats. This cashew database can be limited to a single desktop computer or can be stored in large Server Machines.



Cashew Database

The cashew data are stored in the form of tables. The table consists of rows and columns. The primary and secondary key helps to eliminate data redundancy, enabling systematic storage of data.

The unique data field in a table is assigned a primary key. The primary key helps in the identification of data. It also checks for duplicates within the same table, thereby reducing data redundancy. There are tables, which have a secondary key in addition to the primary key. The secondary key is also called 'foreign key'. The secondary key refers to the primary key of another table, thus establishing a relationship between the two tables.

The development of information system on cashew will be carried out in Visual Basic (VB), a front end tool and Microsoft Access as a back end tool. Since, VB provides features of event driven, GUI (Graphical User Interface), class and modules which helps in object oriented programming, and also provide Object Linking and Embedding (OLE), Dynamic Data Exchange (DDE), Dynamic Link Library (DLL) etc.,

5.9 Development of CD on IPM of Cashew Stem and Root Borers (CSRB)

Cashew crop is prone to an array of insect pests which damage the various parts of the tree causing moderate to severe yield losses. Of these, the major pests occurring commonly in all the cashew growing regions of the country are cashew stem and root borer (CSRB) and tea mosquito bug (TMB). The CSRB is spreading rapidly to the cashew growing regions of India. Due to the death of yielding trees the population density rapidly decreases thereby causing drastic yield reduction and serious losses to the cultivators.

The cashew farmers do not have a correct idea about the pest damage symptoms and the pest management techniques, which has been the main cause for loss of yielding cashew trees. The pest incidence goes unchecked as the pest infestation being internal is inconspicuous and the damage symptoms are identified at the final stages. It is necessary to sensitize the cashew cultivators about various aspects of the pest, including initial symptoms of attack, seasonality,

management practices to be adopted and precautions to be followed to minimize spread of pest incidence.



CD Package on IPM of CSRB

The present knowledge based CD-package on Integrated Management of Cashew Stem and Root Borer will fit in for a better transmission of ideas and initiate discussion to clarify the doubts of cultivators. Also, inclusion of video clippings will help in better understanding of the method of pest removal and further treatment of the CSRB infested trees. This knowledge based CD-package has requisite information on pest biology, damage symptoms, management techniques and precautions to minimise pest infestation which will certainly aid the cashew farmers to manage this pest effectively and thereby realise higher yields.



6. CONCLUDED PROJECTS

6.1: Molecular characterization of cashew using RAPD and Isozyme markers (ICAR Adhoc Project)

Project Leader	: Thimmappaiah (11-3-05 to 31-05-08)
Project Associates	: Mr. Melwyn G.S., SRF (10-12-2004 to 31-7-2006) Ms. Shobha D. SRF (2-9-2006 to 8-5-2007) Mr. Santhosh, W.G., SRF (8-7-2007 to 31-5-2008)
Project Duration	: 3 years 6 months (01-12-2004 to 31-05-2008)

6.1.1 Introduction

Cashew is an important edible nut crop of considerable importance in India. Though it is cultivated on a large area, productivity is low. Genetic improvement in cashew is required to improve its productivity. Germplasm is an important resource for crop improvement. There is a need for efficient management and utilization of these genetic resources. At DCR Puttur, a large germplasm assembly (527) has been made. Characterization of these germplasm is very important before utilizing them in any systematic crop improvement programme. Cashew germplasm is being characterized as per IPGRI Cashew Descriptors. As many of these characters are of agronomic nature and are likely to be influenced by the environmental factors, molecular markers provide a powerful tool for characterization as they are stable and unaffected by the environment. DNA molecular markers like RAPD, ISSR, AFLP and SSR have been used earlier for diversity analysis, phylogenetic study and cultivar identification purpose. Similarly allozyme variation has been used to study diversity.

6.1.2 Objectives

- Standardization of protocol for DNA extraction from leaf samples of cashew
- Standardization of Isozyme extraction and staining protocols and to identify isozymes showing polymorphism.
- Standardization of PCR protocol for RAPD/ISSR markers and identify primers exhibiting polymorphism

- Finger printing of cashew varieties/accessions (Core Collections) using RAPD/ISSR and isozyme markers
- Estimation of the extent of genetic diversity in germplasm.
- Generation of DNA and isozyme profiles of varieties for patenting/identification purpose.

6.1.3 Material and Methods

Leaf samples collected from 172 clonal germplasm accessions and 40 varieties maintained at Directorate of Cashew, Puttur were used for characterization. Isozyme extraction from young leaves of cashew was standardized. In the mini extraction protocol for Isozyme, 100 mg of fresh leaves was ground in a pre cooled pestle and mortar extracted with 1166 μ l of cold extraction buffer [0.05M Tris (pH 8), 0.007 citric acid, 0.1% cysteine HCl, 1% ascorbic acid, 1% polyethylene glycol, 1mM mercaptoethanol, (pH 8)] and centrifugation at 15,000 rpm, at 4°C for 10 min. and the supernatant was used for the enzyme assay. The electrode buffer was Tris-glycine (pH 8.3) and the Isozyme bands were separated on 7.5% native PAGE. The gel bands were visualized following the staining protocols standardized for different enzymes. Genomic DNA was isolated from young cashew leaves using liquid nitrogen following the CTAB method with slight modification. The DNA extracted was quantified through Fluorometer (GE Healthcare, Singapore) and homogeneity was checked on 0.8% agarose gel electrophoresis. DNA was stored at -20°C until further use.

RAPD analysis was carried out with ten selected Operon decamer primers. PCR amplification was performed in 25 μ l mix containing 1X Taq buffer, 3 mM MgCl₂, 200 μ M dNTPs mix, 1 μ M primer, 1.5 units of Taq DNA polymerase (Bangalore Genei) and 50 ng of template DNA following an initial denaturation at 95°C for 2 min, cycle denaturation at 94°C for 1min, annealing at 35°C for 1 min, initial extension at 72°C for 2 min for 35 cycles with final extension at 72°C for 6 min. The amplified products were resolved on 1.5% agarose electrophoresis and the image bands were

acquired with Gel Documentation System (Alpha Innotech Corp. USA). The molecular size of the amplicons was determined with reference to the DNA ladder 100 bp (GE Healthcare) and 1 Kb ladder (Fermentos). Similarly, ISSR analysis was carried out with 10 selected ISSR primers and the PCR reactions were performed in the same way as RAPD except for annealing at 55°C. The amplified products were separated on 2% agarose gel electrophoresis with 0.5X Tris-acetic acid-EDTA buffer. The bands were visualized and acquired as before. Reactions were repeated twice in both.

Bands which are distinct and reproducible were scored as 'present' (1) or 'absent' (0) with all the primers and accessions studied. The discriminating power of primers was assessed by percentage of polymorphism, polymorphic information content (PIC) and the marker index (MI). The PIC content of primers was estimated (Powell *et al.*, 1996; Smith *et al.*, 1997) and the marker index for each was calculated by the formula

$PIC = 1 - \sum f_i^2$, where 'fi' is the frequency of i^{th} allele.

Marker Index (MI) = PIC X no. of polymorphic bands.

The binary data (matrix) prepared was used for calculating Jaccard's coefficient of genetic similarity (Sneath and Sokal, 1973) between all possible pairs of accessions. Similarity coefficient values estimated were used to construct a dendrogram (cluster diagram) using the method of Unweighted Pair Group with Arithmetic Averages (UPGMA) and Principal Co-ordinate Analysis (PCA) analysis was also carried out following the software package NTSYS-pc version 2.02 (Rohlf, 1998). The co-phenetic correlation coefficient was calculated and Mantel test (Mantel, 1967) was performed to check the goodness of fit of a cluster analysis to the matrix.

6.1.4 Results and discussion

6.1.4.1 Finger printing of cashew varieties with Isozyme markers

Thirty varieties of cashew were characterized using Isozymes of 10 enzyme systems namely acid phosphatase (ACP), esterase (EST), peroxidase (PER), aspartate aminotransferase (AAT), glucose -6-phosphate dehydrogenase (GPD), phosphogluco mutase (PGM), phosphogluco isomerase (PGI), leucine aminopeptidase (LAP), malate dehydrogenase (MDH), and shikimate dehydrogenase (SDH). Out of 10

enzymes assayed, glucose -6-phosphate dehydrogenase (GPD) was monomeric with single band and in the remaining, a total of 32 isozyme bands were detected, out of which 21 were polymorphic (64.7%) with an average of 2.3 bands / isozyme. The number of polymorphic bands varied from 1 (PER) to 4 (AAT, SDH). The polymorphic information content (PIC) varied from 0.077 to 0.399 with an average of 0.206. Similarly, marker index (MI) varied from 0.077 to 1.596 with an average of 0.587. Among the different Isozymes, SDH, AAT and PGM were highly informative. Jaccard's similarity co-efficient values between pair of varieties varied from 0.48 (Ullal-1 and Goa - 1 ; NRCC Sel-1 and Ullal-1) to 1.00 (BPP-5 and BPP-6) with an average similarity coefficient of 0.78 indicating low diversity existing among the varieties.

Cluster analysis with UPGMA method grouped the varieties broadly into two groups, one cluster containing two varieties namely Ullal-1 and Bhaskara and the second cluster contained 28 varieties which were further separated into 5 sub clusters (Fig. 6.1). Among the varieties, Ullal-1 and Goa 11/6 were highly divergent and BPP-5 and BPP-6 were genetically highly similar.

6.1.4.2 Finger printing of cashew varieties with RAPD, ISSR and SSR markers

Diversity in forty varieties of cashew was analyzed with RAPD, ISSR and SSR markers individually and by combining markers data of all three types. Marker types were analyzed alone and in combination. RAPD analysis was carried out with 10 selected primers which generated 75 bands, of which 52 were polymorphic (71.8%) with an average 5.2 polymorphic bands per primer. For ISSR analysis also 10 selected ISSR primers were used and generated 88 bands, of which 77 bands (87.5%) were polymorphic. SSR analysis was carried out 15 primer pairs of SSR markers of cashew which generated 33 bands on 3.5% Hi-Res™ agarose, of which 31 bands (93.3%) were polymorphic with an average 2.06 polymorphic bands per primer pair. Polymorphic information content and marker index was computed for each of the markers generated. Among RAPD primers OPO 01, OPO 02 and OPM 18, in ISSR UBC 856 and UBC 857 and in SSR CS-14 primer pair were highly informative. Similarity coefficient values based on Jaccard was computed for each of the marker types and also used to make dendrogram.

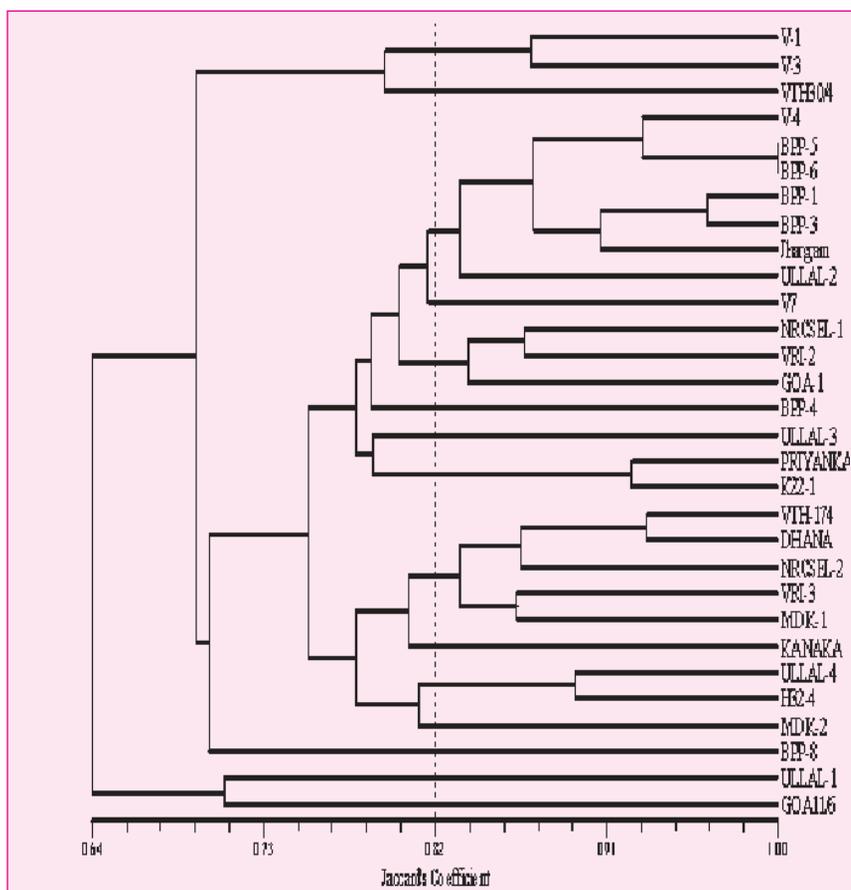


Fig 6.1 : Cluster of 30 varieties based on Isozyme markers

Markers data of RAPD, ISSR and SSR were combined and generated 196 bands, of which 160 bands (81.6%) were polymorphic and produced on an average 4.6 polymorphic bands per primer. The similarity values (Jaccard's) varied from 0.52 to 0.81 in which the highest similarity was observed between Bhaskara and VRI-3 and lowest similarity was observed between V-2 and Kanaka. The average similarity of 0.681 indicated low diversity among the varieties. At 75% similarity, varieties could be broadly grouped in to two groups; first group containing only a single variety Kanaka and the second group was further separated into sub groups and these in to many smaller clusters. In all 10 clusters were distinguished (Fig 6.2). There was intermingling of varieties released from different centres indicating commonness in their lineage and or selection of types for similar set of characters. Among the accessions Kanaka, VRI-2 and V-6 were highly divergent and Bhaskara and VRI-3 were highly similar.

6.1.4.3 Molecular characterization of cashew germplasm using RAPD and ISSR markers

One hundred seventy two germplasm collections maintained at National Cashew Field Gene Bank

(NCFGB) at DCR, Puttur were characterized using both RAPD and ISSR markers. Germplasm represented different cashew growing regions including some exotic collections. RAPD and ISSR analysis was carried out alone and in combination.

RAPD analysis was carried out using nine selected random primers of RAPD which generated a total of 46 bands, of which 40 bands were polymorphic (86.9%), with an average of 4.4 bands per primer. Similarly, ISSR analysis was carried out using 10 selected ISSR primers (8 anchored and 2 non-anchored primers) which generated 61 bands, of which 56 bands were polymorphic (91.8%) with an average of 5.6 polymorphic bands/primer. The polymorphic information content (PIC) and marker index for each of the primers were estimated and along with Jaccard's genetic similarity values between different pair of accessions. Among the RAPD primers OPO-03, OPO-01, OPO-02 and OPM-15 and in ISSR, UBC-856, UBC-865, UBC-857 and UBC-834 were highly informative. Cluster analysis based on similarity values of RAPD and ISSR was also done.

For deriving better phenetic relationship, the markers data of RAPD and ISSR markers were

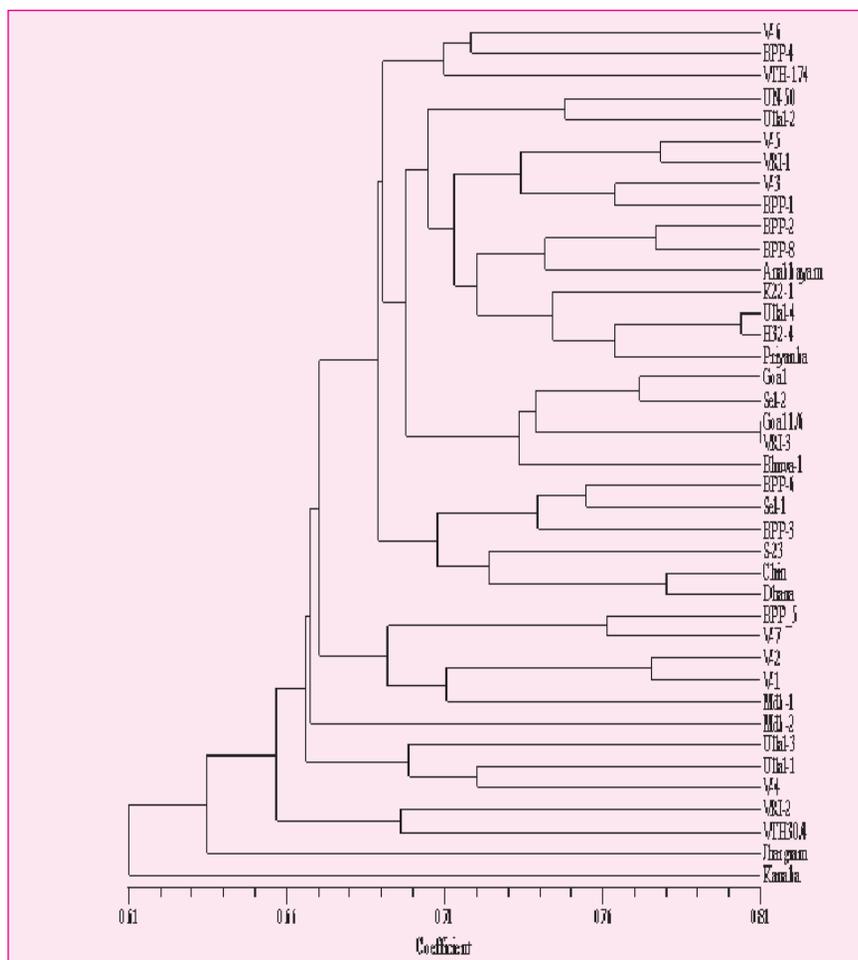


Fig 6.2 : Cluster of 40 varieties based on combined markers (RAPD+ISSR+SSR)

combined and obtained a total of 107 amplified bands, of which 96 bands were polymorphic (89.7%) with an average of 5 polymorphic bands / primer. The PIC content varied from 0.155 to 0.435 with an average of 0.315 and MI content varied from 0.644 to 3.051 with an average of 1.630. The similarity co-efficient (Jaccard's) values between different pair of accessions varied from 0.380 (NRC-432 and NRC-119) to 0.86 (NRC-235 and NRC-216). The cluster analysis with UPGMA method broadly grouped the accessions into two major clusters, one of the major cluster containing two accessions (NRC-432 and NRC-375). The second cluster was further divided into two sub-clusters, one sub-cluster containing single accession (NRC-142) and the second sub-cluster was further divided into two smaller clusters which could be further divided into several minor clusters. In all, 17 clusters were distinguished (Fig 6.3). From 17 clusters, 55 accessions were identified to form 'Core Collections'. For 'Core Collections', unique genotypes like CNSL free types, purple genotype, dwarf types, wild species and diverse genotypes identified from PCA plot and at least one accession from each of the cluster were considered.

Matrix correlation between RAPD and ISSR was found to be low (0.103) indicating no correspondence among the markers as each of these are different. RAPD is a dominant marker and scans the random sequence on the genome while ISSR is a better marker targeting microsatellite motif. Both of the markers employed alone and in combination proved useful for estimating diversity in germplasm.

6.1.4.4 Conclusions

The study showed the efficacy of different markers (RAPD, ISSR and SSR) for diversity analysis and differentiation of varieties / germplasm of cashew. Isozyme and DNA markers could be used for characterization. Thirty varieties and species including interspecific hybrids could be characterized using Isozyme markers. Forty released varieties of cashew were finger printed using RAPD, ISSR and SSR markers. Here the diversity was low as they were selected for only limited useful characters. Molecular characterization of 172 accessions using RAPD and ISSR markers indicated moderate diversity. Out of 172

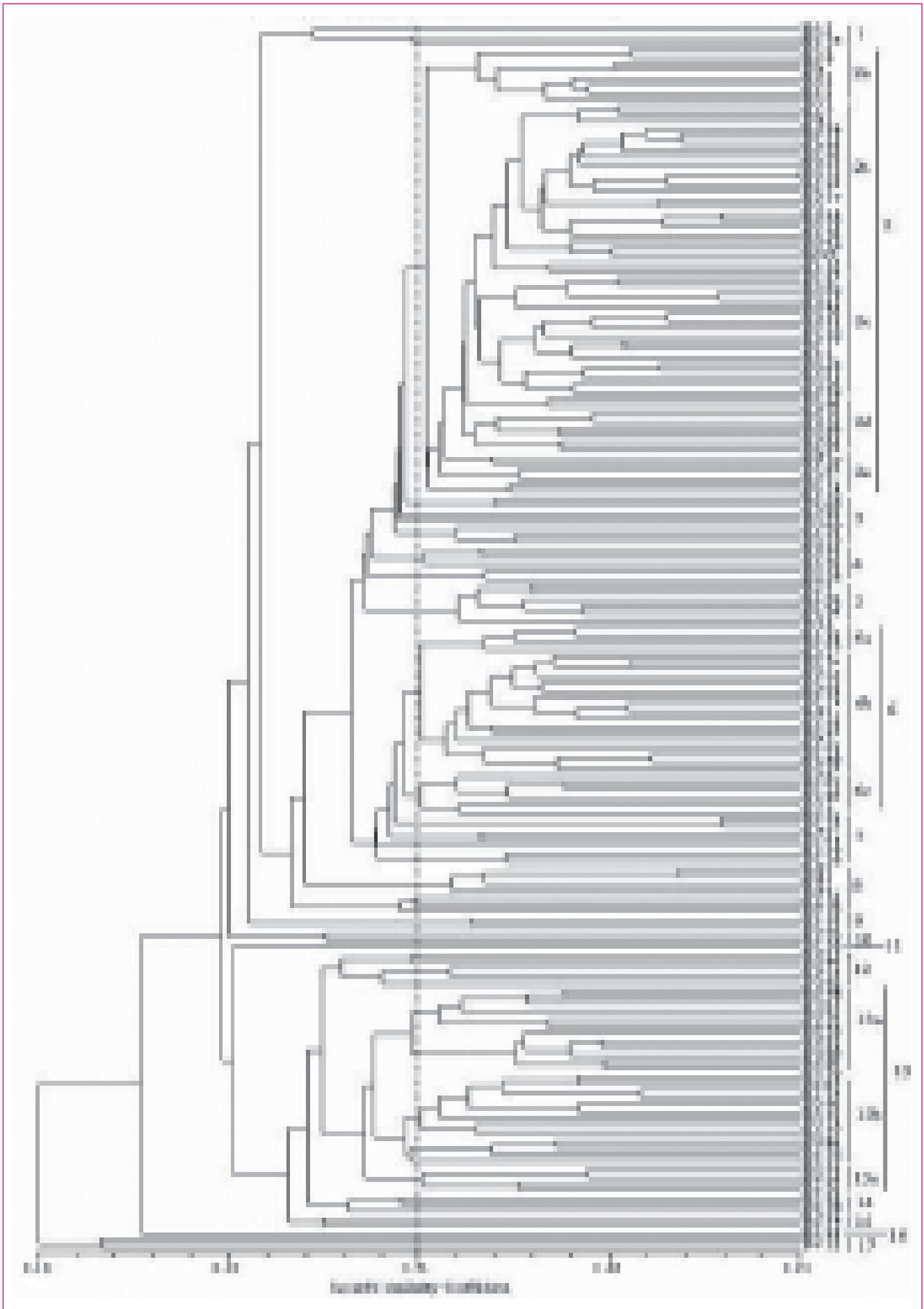


Fig 6.3 : Cluster of 172 accessions based on combined markers (RAPD+ISSR)

accessions 55 accessions were identified to form 'Core Collections'. Study could identify accessions which are highly divergent and less divergent.

6.1.4.5 Publications

1. Thimmappaiah, Santhosh, W.G., Shobha, D., Melwyn, G.S., 2009. Assessment of genetic diversity in cashew germplasm using RAPD and ISSR markers. *Sci. Hortic*, 120, 411-417.
2. Thimmappaiah., Melwyn, G. S., Shobha, D., Shirly Raichal Anil., 2009. Assessment of cashew species for molecular diversity. *J. Plantation Crops*, 37 (2), 146-151.

6.2 Efficacy of soil and water conservation techniques coupled with organic and inorganic manuring in cashew garden grown in slope areas

Expt B: Evaluation of different soil and water conservation measures in relation to soil moisture availability and yield of cashew plantations grown in steep slopes

Project Leader	Dr. R. Rejani
Project Associate	Dr. N. Yadukumar
Project Number	2.8
Project Duration	2003 - 2010 (7 years)

6.2.1 Introduction

In India cashew is generally grown as a rainfed crop along steep slopes of hillocks or on neglected land unsuitable for any other crop. The largest area under cashew cultivation is along the west coast region of India where the mean annual rainfall ranges from 3000 to 3500 mm with 80% of its contribution during June to September. The runoff and soil erosion are very high in steep slopes. Due to the non-uniform distribution of rainfall, cashew experiences severe moisture stress from January to May which adversely affects its flowering and fruit set, resulting in immature nut drop and lower productivity of cashew gardens. During fruiting season of cashew (February to May), a mean rainfall of around 67 to 415 mm is received. The water deficit is highest during March to May (112 to 183 mm). The average productivity of cashew in India and Karnataka are 0.90 and 0.72 t/ha/year respectively against the target of 1 t/ha/year. However, there is a possibility of increased production by adopting soil and water conservation

measures with high yielding varieties of cashew. With proper soil and water conservation, the soil loss can be minimized; the runoff water from post-monsoon and pre-monsoon rainfall can be harvested and made available to the plant during the critical period.

6.2.2 Objectives

- Development of suitable soil and water conservation technique for cashew garden grown along steep slopes which can increase the cashew nut yield and net benefit from the cashew garden.
- Determination of the effect of soil and water conservation measures in reducing runoff and soil loss and in increasing the soil moisture content and soil nutrient content of cashew garden.

6.2.3 Material and Methods

The experiment was conducted at Directorate of Cashew Research Experimental Station, Puttur, during 2003-2009. The climate is seasonally wet, hot humid with dry season from January to May. The fruit development in cashew takes place during this period. The mean annual rainfall ranges from 3000 to 3500 mm with 80% of its contribution during June to September. The soil is lateritic, characterised by very low water holding capacity (23 % in field capacity) and texturally, the soil is sandy clay loam. It is slightly acidic (pH - 5.5), low in N content (ranges from less than 250 kg/ha), low in P₂O₅ (less than 12.5 kg/ha) and K₂O (less than 141 kg/ha) content. This experiment was laid out with the following five treatments in a barren hillock with a slope upto 40 %, where the top soil was eroded and the substratum was exposed. The treatments were modified crescent bund (at 2 m radius having a crescent shaped bund of 6 m length, 1m width and 0.5 m height) (T1), staggered trenches with coconut husk burial between two rows of cashew (trenches of size 5 m length, 1m width and 0.5 m depth in the middle of four plants with coconut husk buried) (T2), reverse terraces (2 m length, 2 m width and 0.7 m depth of cut) (T3), catch pits (3 m length, 0.5 m width and 0.5 m depth) (T4) and control plot without any soil and water conservation measure (T5). It was laid out in RBD with four replications having 25 grafts of Madakkathara-2 variety planted along the contour in the year 2003. Later, two treatments of mulching for cashew plants using locally available plant materials (T6) and fodder stylosanthes (T7) was imposed for five plants each in the soil and water conservation experiment. The growth

of plants, cashew nut yield, runoff, soil loss, infiltration rate of the soil, soil moisture content and nutrient content of the soil were recorded.

6.2.3.1 Growth, cashew nut yield and net profit

The growth data was recorded from 2003-10 and yield data from 2005-2010. Nuts were collected manually from the ground under each tree, counted and weighed. The nut yield/tree was calculated (mean nut weight x total number of nuts/tree).

6.2.3.2 Run off and soil loss

The Coshokton Wheel and its accessories were fixed in the field in each treatment plot of one replication to determine the runoff and soil loss. During rainy season the stage level recorder was set daily to determine the runoff. The peak runoff for each intensity of rainfall was recorded and cumulative run off for the whole rainy season was calculated.

6.2.3.3 Infiltration and soil moisture characteristics

Infiltration rate of the soil at the upstream, middle and downstream of the hill was recorded using Double Ring Infiltrometer.

6.2.3.4 Soil moisture content

The soil samples at 0-30 cm, 31-60 cm and 61-90 cm depths were collected from base of the plant at 1.5 m radius and soil moisture contents under the different treatments were determined by gravimetric method (2003-09) and TDR soil moisture profiling system (2009-10) during flowering and fruiting period.

6.2.3.5 Nutrient content of soil and leaf

Before fertilizer and manure application, soil samples from different soil and water conservation treatments were analyzed for organic carbon, P_2O_5 , K_2O , Ca, Mg, Zn, Mn, Cu and Fe. The nutrient content of the soil and leaf were determined during 2006-08. Soil at three depths (upto 90 cm) and fourth or index leaves at the time of flushing were oven dried at 70° C and powdered. Nitrogen was determined using Kjeltak Auto-Analyzer, P was estimated colorimetrically by Vanado Molybdo Phosphate method, K was estimated using flame photometer and Ca, Mg, Fe, Zn, Mn and Cu were determined using Atomic Absorption Spectrophotometer (AAS) (wet digestion method).

6.2.3.6 Groundwater level

The ground water elevation data was measured before and after adopting soil and water conservation measures for 500 plants with modified crescent bunds. The elevation of the observation points were recorded using Global Positioning System and the depth to groundwater level was measured for determining the groundwater elevation from time to time.

6.2.4 Results and Discussion

6.2.4.1 Growth and cashew nut yield

Stem girth (Fig.6.4) and canopy spread (Fig. 6.5) was higher in modified crescent bund treatment, coconut husk burial and reverse terrace treatments and lowest in control and catch pit treatments. During 2008-09, the higher cashew nut yields were obtained in coconut husk burial treatment (2.04 t/ha), modified crescent bund (2.03 t/ha) and reverse terrace treatments (1.94 t/ha), compared to catch pit (1.39 t/ha) and control (1.48 t/ha). During the seventh year (2009-10) also the yield was higher in coconut husk burial (1.97 t/ha), modified crescent bund (2 t/ha/year) and reverse terrace (1.71 t/ha/year) treatments compared to catch pit (1.57 t/ha/year) and control (1.55 t/ha/year) treatments (Table 6.1). Increase in yield in treatments with mulch was not significant.

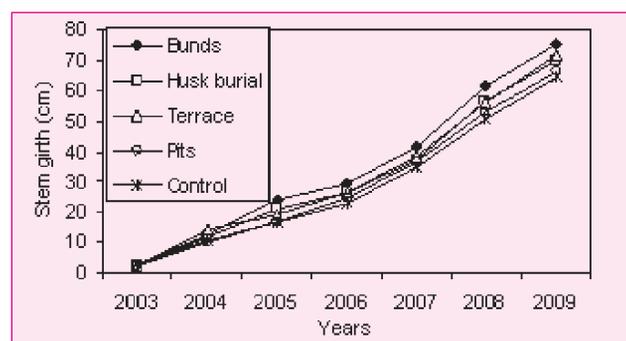


Fig.6.4: Effect of soil and water conservation on stem growth

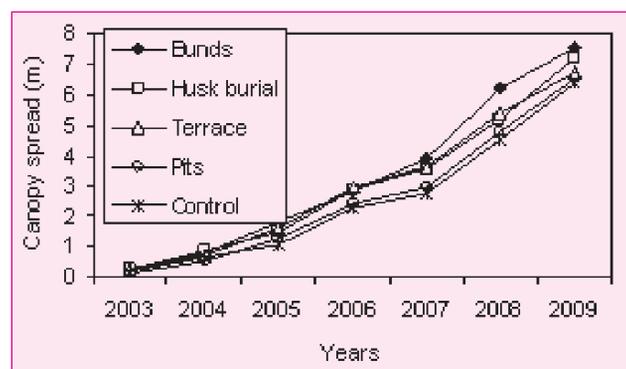


Fig.6.5: Effect of soil and water conservation on canopy spread

The *insitu* soil and water conservation structures effectively harvested the pre- monsoon rainfall and increased the cashew yield significantly. A second time flowering and fruit set was observed after the pre-monsoon rain during 2008-09. The cumulative yield of five harvests was also high in coconut husk burial (6.6 t/ha), and modified crescent bund treatments (6.45 t/ha) compared to control (4.88 t/ha) and other treatments.

6.2.4.2 Net profit

The net profit from cashew garden for the first seven years (5 harvests) with proper soil and water conservation ranged from Rs. 1,82,024 to Rs. 2,02,436 /ha whereas, in control it was Rs. 1,44,652 /ha. Hence, the barren land can be converted into cashew garden with proper soil and water conservation for improving the net benefit (Table 6.2).

Table 6.1: Variation of yield under different soil and water conservation treatment

Treatment	Yield (t/ha)					Cumulative
	2005- 06	2006- 07	2007- 08	2008-09	2009-10	
Modified crescent bund	0.355	0.671	1.41	2.03	2.00	6.45
Staggered trenches with coconut husk burial	0.390	0.702	1.50	2.04	1.97	6.60
Reverse terraces	0.336	0.654	1.24	1.94	1.71	5.88
Catch pits	0.316	0.561	1.21	1.39	1.57	5.05
Control	0.262	0.451	1.14	1.48	1.55	4.88
Mean	0.332	0.608	1.27	1.77	1.76	5.77
CD (5%)	0.057	0.152	0.088	0.224	0.147	0.14

Table 6.2: Cost of cultivation and net profit (Rs.) from cashew garden with soil and water conservation for the first seven years

Cost of cultivation	Modified crescent bund	Coconut husk burial	Reverse terraces	Catch pits	Control
Weeding once in a year	14000	14000	14000	14000	14000
Manuring	4489	4489	4489	4489	4489
Plant protection measures	2395	2395	2395	2395	2395
Digging pits and soil and water conservation	7986	14010	5978	5604	4016
Picking nuts	4300	4400	3920	3367	3253
Total Labour cost	33170	39294	30782	29855	28154
Cost of materials					
Fertilizers and manures	17491	17491	17491	17491	17491
Plant protection Chemicals	4903	4903	4903	4903	4903
Total cost of cultivation	55564	61688	53176	52249	50548
Nut yield (tonnes/ha)	6.45	6.60	5.88	5.05	4.88
Income	258000	264000	235200	202000	195200
Net profit	202436	202312	182024	149751	144652

6.2.4.3 Infiltration and soil moisture characteristics

The maximum infiltration rate was 43.9 cm/h. The constant infiltration rate was 11cm/h. The accumulated infiltration (y) was fitting into equation, $y = 1.3299x0.6642$ with an R2 value of 0.9988, where, x is the elapsed time. The available soil moisture ranged from 12 to 22% on dry basis.

6.2.4.4 Soil moisture content

The mean soil moisture content in modified crescent bund and coconut husk burial treatments was on par (15.6% and 15.8% on dry basis respectively in March) and was high compared to control (11.6% on

dry basis in March) and other treatments (reverse terrace - 14.6% and catch pit - 12.7% on dry basis) (Table 6.3). Similar trend with soil moisture distribution was observed during other months (Table 6.4). The available soil moisture ranged from 12 to 22 % on dry basis. The soil moisture content at all the three depths (0-90 cm) in soil and water conservation treatments was in the available soil moisture range and ranged from 12.9 to 18.2 % on dry basis. The soil moisture content in the top two layers of soil (0-60 cm) in the control plot was 10.3 to 11.4 % on dry basis respectively and was below the available soil moisture range in March itself (Table 6.4).

Table 6.3: Mean soil moisture content between March 2006 and 2010 on dry basis (%)

Treatment	Depth (cm)			Mean
	0-30	30-60	60-90	
Modified crescent bunds	13.3	16.0	17.6	15.6
Coconut husk burial	13.4	16.0	18.2	15.8
Reverse terraces	12.9	14.7	16.4	14.6
Catch pits	11.3	12.5	14.2	12.7
Control	10.3	11.4	13.0	11.6
Mean	12.0	14.1	15.9	14.0
CD (5%) Treatment				1.4
CD (5%) Depth				0.4

Available soil moisture ranged from 12 to 22% on dry basis

Table 6.4: Variation in mean soil moisture content on dry basis between 2006 and 2010 (%)

Treatment	Mean soil moisture					
	Dec	Jan	Feb	Mar	Apr	May
Modified crescent bunds	19.9	18.6	17.2	15.6	12.1	23.1
Coconut husk burial	20.5	18.6	17.1	15.8	12.1	22.5
Reverse terraces	19.0	17.5	16.3	14.3	11.4	22.0
Catch pits	17.5	16.5	15.3	12.7	10.8	18.7
Control	16.8	15.4	12.7	11.6	10.6	17.3
CD (5%) Treatment	2.1	2.0	1.8	1.4	0.5	0.48
CD (5%) Depth	0.7	0.6	0.5	0.4	0.3	0.17

A rainfall of 50, 49.4 and 26.9 mm was observed during April 2005, May 2006 and April 2009 respectively and no rainfall was received before soil sample collection during other period. After the pre-monsoon rainfall of 50 mm in April 2005, almost same soil moisture content was observed in the top two layers of soil in all the treatments including control (20.0 to 21.4% on db in top layer and 18.0 to 20.3% on db in second layer). Soil moisture content in the third layer was higher in the coconut husk burial and crescent bund treatments (19.1 and 19.0% on db) and lowest in the control plot (16.6% on db). Similar trend was observed during May 2006 and April 2009. The increased soil moisture content in the lower layers in soil and water conservation treatments showed the effectiveness of soil and water conservation techniques in conserving the pre-monsoon rainfall.

6.2.4.5 Runoff and soil loss

The mean runoff was less in case of staggered trenches with coconut husk burial (20%), modified crescent bunds (22%), and reverse terrace treatments

(27%) compared to control plot (37%). A mean annual rainfall of 3031 mm was recorded during this period. The soil loss was also less in the case of modified crescent bund and coconut husk burial treatments (68 and 58% of control) compared to control and other treatments.

6.2.4.6 Soil and leaf nutrient content

The organic carbon content (OC%), P₂O₅ and K₂O content of the soil at 0 to 60 cm depth was high in coconut husk burial, modified crescent bund and reverse terrace treatments (organic carbon content - 0.57 to 0.66% compared to 0.44% in control, P₂O₅ content - 4.6 to 7.0 kg/ha compared to 2.0 kg/ha in control, K₂O content - 57.8 to 65 kg/ha compared to 40.5 kg/ha in control). Coconut husk, a rich source of K enhanced the intensive growth of roots inside the coconut husk burial trenches. The minor nutrients were on par in different treatments and the micronutrients were high in soil and water conservation treatments (Table 6.5). The major and micronutrients present in leaf was also high in case of soil and water conservation treatments (Table 6.6).

Table 6.5: Nutrient status of the soil in different treatment plots (July 2008)

Treatment	OC%	P (kg/ha)	K (kg/ha)	Ca (kg/ha)	Mg (kg/ha)	Cu (mg/kg)	Zn (mg/kg)	Mn (mg/kg)
Modified crescent bund	0.60	6.9	96.2	2.29	0.51	2.34	7.28	41.48
Staggered trenches with coconut husk burial	0.66	5.8	101.1	0.42	0.47	2.16	5.27	20.37
Mulching with <i>Stylosanthus</i>	0.64	6.6	155	3.46	0.81	1.99	1.15	26.56
Local mulch application	0.57	6.0	144	3.32	0.81	2.45	5.6	42.2
Control	0.44	1.3	63.3	0.30	0.15	1.79	1.01	6.53
CD (5%)	0.08	1.33	5.94	1.81	0.22	0.12	0.97	2.26

Table 6.6: Effect of different treatment on mineral leaf nutrient

Treatment	N (%)	P (%)	K (%)	Zn (ppm)	Mn (ppm)	Cu (ppm)
Modified crescent bund	1.80	0.51	0.32	1.8	4.5	0.9
Coconut husk burial	1.84	0.41	0.39	1.2	4.7	0.8
Reverse terraces	1.79	0.39	0.37	1.5	5.2	0.9
Catch pits	1.75	0.32	0.29	1.0	3.8	0.9
Control	1.63	0.18	0.23	0.8	2.8	0.2
CD (5%)	0.20	0.07	0.08	NS	1.2	0.1

6.2.4.7 Groundwater level

The *insitu* soil and water conservation measures adopted for 500 cashew plants harvested the rainwater, increased the percolation time and recharged the groundwater. Hence, the groundwater level in nearby ponds and wells improved by 0.35 m after imposing the soil and water conservation for cashew (Fig. 6.6).

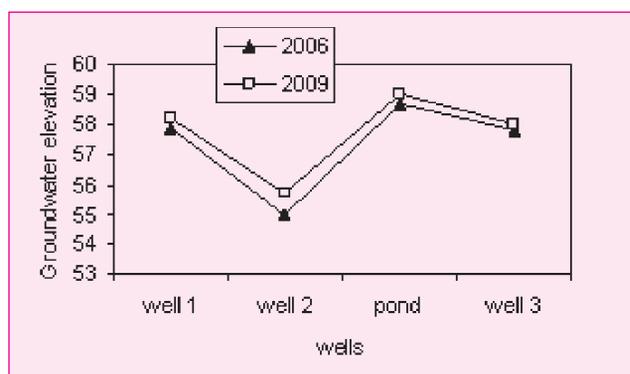


Fig. 6.6: Groundwater elevation before and after imposing soil and water conservation (March)

6.2.5 Conclusions

Soil and water conservation measures such as modified crescent bund and coconut husk burial treatments increased the growth of cashew plants and cumulative yield of five harvests (coconut husk burial - 6.6 t/ha and modified crescent bund - 6.45 t/ha) compared to control (4.88 t/ha) and other treatments. These treatments increased the yield of cashew by 30%. The net profit from cashew garden for the first seven years (5 harvests) with proper soil and water conservation ranged from Rs. 1,82,024 to Rs. 2,02,436 /ha whereas, in control it was Rs. 1,44,652 /ha. Modified crescent bund and coconut husk burial treatments reduced the annual runoff and soil loss, increased the mean soil moisture content (15.6% and 15.8 % on dry basis compared to 11.6% on dry basis in control in March), nutrient content of the soil and leaf. The harvested rainwater increased the ground water level in nearby wells and ponds. Hence, the barren land even in steep slopes can be effectively utilized for cashew cultivation with proper soil and water conservation measures like modified crescent bund and coconut husk burial.

6.2.6 Publications

- 1) Yadukumar, N. and Rejani, R. 2004. Evaluation of soil and moisture conservation techniques coupled with manuring in cashew grown under medium slope. *Journal of Plantation Crops*, 32 (Suppl.), pp.190-195.
- 2) Rejani, R. and Yadukumar, N. 2006. Effect of soil and water conservation techniques for cashew plantations grown on steep slopes. *Journal of Plantation Crops*, 34(3): 304-308.
- 3) Yadukumar, N. and Rejani, R. 2006. Temporal and spatial variation of soil moisture content and development of a yield model based on soil moisture content for the cashew. *Journal of Plantation Crops*, 34(3): 364-367.
- 4) Rejani, R. and Yadukumar, N. 2007. Response of cashew plantations grown in slope areas of West Coast region of India for soil and water conservation measures. Proceedings of the National seminar on Research, Development and Marketing of Cashew, 20- 21st November, Goa, pp: 63-64.
- 5) Yadukumar, N. and Rejani, R. 2008. Soil and Water Management in Cashew Plantations. Technical Bulletin No.10. 16pp. NRC-Cashew, Puttur, D.K., Karnataka.
- 6) Yadukumar, N., Rejani, R. and Bhat, M.G. 2009. Scope for adoption of soil and water management techniques to increase cashew yields in Andaman and Nicobar Islands. National Workshop cum seminar on status and future strategies for Horticultural development in Andaman and Nicobar Islands. Central Agricultural Research Institute, Portblair, January 23-25.
- 7) Yadukumar, N., Rejani, R. and Prabhakar, B. 2009. Fertigation for efficient water and nutrient management in high density cashew plantation. *Journal of Plantation Crops*, 37(2): 102-110.

6.3 Paid up Trial : Evaluation of newer insecticides against tea mosquito bug *Helopeltis antonii* Signoret

Project Leader : Dr. P. Shivarama Bhat
 Project Number : Paid up
 Project Duration : 2005-2010

6.3.1 Introduction

It is suggested to use insecticides judiciously at the time of flushing, flowering and fruiting for the effective management of tea mosquito bug (TMB). Carbaryl and lambda cyhalothrin are the commonly used insecticides for the management of this pest. The alternate insecticides are essential to avoid the usage of same molecule again and again so that chances of insects gaining resistance may be avoided. The present project was undertaken at evaluating the newer insecticides for their efficacy.

6.3.2 Objectives

- Studying the efficacy of newer insecticides against TMB under field condition.
- Studying the residual toxicity of the newer insecticides against TMB.

6.3.3 Results and discussion

6.3.3.1 Identification of alternate insecticides for the management of TMB

Fenpropathrin (Meothrin 30 EC) supplied by M/S Sumitomo Chemical, India, Mumbai; Spray Oil supplied by M/S Indian Oil Corporation, Mumbai and Phalada III C1 supplied by M/S Phalada Agro Research Foundation Pvt. Ltd, Bangalore were evaluated against TMB under field condition during 2005-08 (three seasons). The sprays were given at flushing, flowering and fruiting stages. Damage on shoots was assessed after one month of third spray on 0 - 4 scale. The damage grade was recorded on 52 shoots in each tree and the mean damage was worked out. The damage rating (0.26) in fenpropathrin (0.02%) was on par (0.20) with the recommended insecticide λ - cyhalothrin (0.003%). In untreated check, the damage rating was 1.21. Spray Oil and Phalada III C1 were less effective compared to λ - cyhalothrin (0.003%). There was no significant difference in the natural enemy complex in the treated plots and untreated control. The average number of predators/panicle ranged from 0.80 - 0.94 in the fenpropathrin treated plots compared to 0.95 in the untreated control (Table 6.7).

Table 6.7: Efficacy of newer insecticides against TMB under field condition

Treatment	2005-06		2006-07		2007-08		Mean	
	Damage (0-4 scale)	Predators/panicle						
Fenpropathrin (0.02%)	0.14 (0.39)a	0.66 (0.82)	0.27 (0.52)a	0.82 (0.91)	0.36 (0.64)a	0.92 (0.96)	0.26 (0.52)a	0.80 (0.90)
Fenpropathrin (0.03%)	0.07 (0.28)a	0.71 (0.85)	0.29 (0.55)a	1.00 (1.01)	0.24 (0.53)a	1.10 (1.05)	0.20 (0.46)a	0.94 (0.97)
Spray oil (1%)	0.71 (0.84)b	0.89 (0.95)	1.07 (1.04)b	0.72 (0.85)	0.69 (0.86)b	0.83 (0.92)	0.82 (0.91)b	0.81 (0.91)
Spray oil (2%)	0.43 (0.66)b	0.73 (0.86)	0.99 (1.00)b	1.03 (1.02)	0.78 (0.91)b	1.08 (1.04)	0.73 (0.86)b	0.97 (0.99)
Phallada III C (0.1%)	0.66 (0.82)b	0.88 (0.94)	0.86 (0.93)b	0.93 (0.97)	1.05 (1.04)b	0.98 (.99)	0.86 (0.93)b	0.93 (0.97)
λ - cyhalothrin (0.003%)	0.15 (0.40)a	0.64 (0.80)	0.22 (0.48)c	0.93 (0.97)	0.22 (0.51)a	1.03 (1.02)	0.20 (0.45)a	0.87 (0.94)
Untreated control	1.03 (1.02)c	0.76 (0.88)	1.68 (1.30)c	0.95 (0.98)	1.68 (1.31)c	0.95 (0.98)	1.46 (1.21)c	0.95 (0.98)
		NS		NS		NS		NS

6.3.3.2 Efficacy of fenpropathrin against TMB under field condition in larger plots

Fenpropathrin was evaluated against TMB under field condition in larger plots during 2008-10. Sprays were given at flowering and fruiting stages. Damage on shoots was assessed after one month of second spray in 0 - 4 scale. The damage grade was recorded in 52 shoots on each tree and mean damage was worked out. The damage rating (0.49) in fenpropathrin (0.02%) was on par (0.33) with the recommended insecticide λ - cyhalothrin (0.003%). In untreated check, the damage rating was 1.22. There was no significant difference in the natural enemy complex in the treated plots and untreated control. Benefit: cost ratio for fenpropathrin was comparable with λ - cyhalothrin (Table 6.8).

6.3.3.3 Efficacy of fenpropathrin against TMB under laboratory conditions

In the laboratory confirmatory trial, fenpropathrin was found to induce 100 per cent mortality of both nymphs and adults of TMB suggesting the higher toxicity.

6.3.4 Conclusion

The damage rating in fenpropathrin (0.02%) was on par with the recommended insecticides λ - cyhalothrin (0.003%). Benefit: cost ratio for fenpropathrin was also comparable with λ - cyhalothrin.

6.3.5 Publication

Bhat P.S. and Raviprasad T.N. 2007. Management of tea mosquito bug *Helopeltis antonii* Sig. with newer insecticide/products. National Seminar

on Research, Development, and Marketing of Cashew. ICAR Research Complex for Goa.pp 80-81.

6.4 Assessment of bioavailability of minerals in cashew

Project Leader	Dr. K.V. Nagaraja
Project Number	4.10
Project Duration	April 2007 to March 2010

6.4.1 Introduction

Released varieties of cashew have been analysed for various biochemical composition. These include kernels, testa, shell, cashew apples, apple pomace and apple powder. Cashew kernels of released varieties have been characterized for protein, starch, sugars, amino acids, fat and minerals. Similarly cashew kernel testa of released varieties and industrial samples have been analysed for protein, starch, sugars, tannin and minerals. Cashew apple pomace (residue after extraction of juice) of released varieties has been analysed for various biochemical constituents. Cashew processing by-products like cashew shell after extraction of CNSL, cashew kernel testa, cashew apple pomace have been analysed for biochemical constituents. It has been shown that mineral composition of cashew kernel, testa and pomace of released varieties exhibit a wide variation. As minerals play an important role in human nutrition particularly Fe, Zn, Cu, Mn and Se, there is a need to assess the bioavailability of these minerals among different released varieties. This will help in developing suitable cereal / pulses blends for enriching the minerals keeping in view of their bioavailability. As such the present project was undertaken

Table 6.8: Efficacy of newer insecticides against TMB under field condition in larger plots

Treatment	Damage (0-4 scale)			Predators/panicle			Benefit Cost ratio	
	2008-09	2009-10	Mean	2008-09	2009-10	Mean	2008-09	2009-10
Fenpropathrin (0.02%)	0.47 (0.72)a	0.52 (0.73)a	0.49 (0.71)a	0.98	1.01	1.00	1.66:1.00	1.78:1.00
λ - cyhalothrin (0.003%)	0.24 (0.54)a	0.42 (0.66)a	0.33 (0.58)a	1.06	0.99	1.03	2.07:1.00	2.17:1.00
Untreated control	1.72 (1.33)b	1.23 (1.12)b	1.48 (1.22)b	0.91	1.08	1.00	-	-
				NS	NS	NS		

6.4.2 Objectives

The main objective was to identify cashew varieties with better per cent bioavailability of minerals

6.4.3 Results and discussion

Mineral content of defatted kernel flour, methanol extracted apple powder and testa of released varieties of cashew in both acid and proteolytic enzyme digests are presented in Tables 6.9 to 6.14. Variability of

mineral content in acid and enzyme digests is presented in Table 6.15. Variability in per cent bioavailability of minerals among released varieties is presented in Table 6.16. Number of varieties showing nil per cent bioavailability of minerals in different flour samples is presented in Table 6.17. Varieties showing nil percent bioavailability of minerals in all the three flour samples analysed is presented in Table 6.18.

Table 6.9: Mineral content in the acid digest of defatted cashew kernel flour ($\mu\text{g}/100\text{mg}$)

Variety	Fe	Cu	Mn	Zn	Se
Ullal 1	2.709	1.113	0.817	5.429	8.157
Ullal 2	2.166	1.385	0.414	5.272	3.089
Ullal 3	2.629	1.252	0.422	4.166	6.156
Ullal 4	3.432	1.498	0.833	5.606	nd
UN 50	3.024	1.094	0.697	5.215	nd
Chintamani 1	5.252	0.893	0.655	6.578	nd
NRCC Sel 1	0.809	2.307	1.446	2.132	2.189
NRCC Sel 2	15.056	2.55	1.411	1.723	3.22
Bhaskara	9.776	2.488	0.954	1.923	4.262
VRI 1	12.042	2.696	1.785	2.274	1.325
VRI 2	8.567	2.936	1.456	1.82	3.415
VRI 3	4.734	0.722	0.911	14.161	nd
V 1	5.73	0.629	0.851	1.953	2.64
V 2	6.021	0.955	1.657	4.079	3.188
V 3	8.633	0.966	1.893	4.883	1.344
V 4	4.813	0.839	2.058	4.959	2.714
V 5	6.13	0.935	2.21	5.414	10.834
V 6	4.05	0.909	1.312	5.309	2.63
V 7	10.656	2.384	0.822	2.306	4.573
BPP 1	3.966	0.915	1.692	19.107	nd
BPP 2	3.877	0.962	1.259	21.768	nd
BPP 5	4.218	1.147	1.695	20.137	nd
BPP 6	4.266	1.171	1.256	22.68	nd
BLA39-4	3.174	0.907	2.189	5.31	nd
Kanaka	3.23	2.884	1.314	4.865	nd
Akshaya	9.495	3.363	0.969	7.589	2.361
Dharasri	3.272	1.734	0.806	4.952	nd
Dhana	3.727	3.352	1.135	5.612	nd
Amrutha	8.716	2.224	1.452	2.245	2.547
Anagha	11.27	2.084	0.936	2.267	4.513
Priyanka	12.524	1.283	1.531	2.521	12.59
Sulabha	10.712	2.461	1.376	2.54	4.179
NDR 2-1	15.645	1.10	1.907	2.172	11.03
Jhargram 1	3.723	0.834	1.504	19.893	nd
Bhubaneswar 1	2.302	1.877	1.395	5.379	11.512
CD(5%)	1.232	0.236	0.318	1.892	
SEd	0.617	0.118	0.159	0.948	

Table 6.10: Mineral content in the acid digest of methanol extracted cashew apple powder ($\mu\text{g}/100\text{mg}$)

Variety	Fe	Cu	Mn	Zn	Se
Ullal 1	7.759	1.187	2.717	1.88	2.86
Ullal 2	6.757	2.434	1.553	1.964	2.14
Ullal 3	2.612	1.014	1.564	1.407	4.50
Ullal 4	2.759	1.355	1.904	1.996	2.19
UN 50	13.07	1.373	3.239	1.558	1.75
Chintamani 1	4.916	0.63	1.562	1.637	4.31
NRCC Sel 1	3.583	2.54	1.842	1.755	9.57
NRCC Sel 2	6.832	1.338	1.525	0.756	4.556
Bhaskara	7.697	0.963	0.638	1.291	3.256
VRI 1	3.552	1.385	3.583	2.852	3.808
VRI 2	5.641	1.044	0.715	1.30	1.483
VRI 3	4.18	1.533	1.766	1.583	nd
V 1	2.639	0.55	0.834	0.711	nd
V 2	7.213	1.505	0.893	0.856	nd
V 3	5.42	0.976	1.209	0.823	nd
V 4	4.989	1.975	1.031	0.994	nd
V 5	7.874	2.158	0.996	0.566	nd
V 6	8.984	1.703	0.787	nd	nd
V 7	5.878	1.971	0.621	2.231	2.692
BPP 1	6.21	1.824	2.274	2.776	nd
BPP 2	6.15	1.40	1.821	1.607	nd
BPP 5	7.73	1.92	1.881	1.846	nd
BPP 6	21.63	3.73	2.593	6.03	nd
BLA39-4	10.25	0.964	2.562	1.428	32.88
Kanaka	6.98	1.023	2.263	1.977	20.67
Akshaya	7.89	2.514	2.09	2.32	nd
Dharasri	11.01	2.411	2.24	0.92	1.98
Dhana	12.34	1.086	1.658	2.308	nd
Amrutha	8.38	2.844	1.88	1.91	5.45
Anagha	8.63	2.802	1.25	1.36	1.211
Priyanka	7.31	1.437	2.011	2.458	25.06
Sulabha	15.95	2.662	1.87	2.96	1.197
NDR 2-1	126.43	1.47	5.007	2.651	9.63
Jhargram 1	17.78	4.84	1.394	4.14	nd
Bhubaneswar 1	60.91	1.727	3.08	2.887	19.50
CD(5%)	5.778	0.475	0.675	0.453	5.144
SEd	2.897	0.238	0.338	0.227	2.549

Table 6.11: Mineral content in the acid digest of methanol extracted cashew kernel testa ($\mu\text{g}/100\text{mg}$)

Variety	Fe	Cu	Mn	Zn	Se
Ullal 1	30.34	1.997	nd	3.021	15.23
Ullal 2	11.39	2.464	0.60	1.586	9.40
Ullal 3	11.53	1.918	0.413	nd	6.61
Ullal 4	24.88	4.322	0.245	nd	1.28
UN 50	16.51	2.723	0.203	5.478	8.72
Chintamani 1	26.27	2.197	nd	7.107	23.61
NRCC Sel-1	12.48	3.319	9.76	4.023	47.76
NRCC Sel-2	24.8	2.819	8.65	10.687	61.70
Bhaskara	9.29	1.909	5.99	2.608	31.21
VRI 1	9.81	2.376	7.83	7.98	35.62
VRI 2	38.84	1.815	5.77	24.47	53.30
VRI 3	14.815	2.168	3.989	2.769	11.99
V 1	19.46	2.197	nd	7.107	23.61
V 2	19.41	0.808	nd	9.206	49.34
V 3	71.97	2.36	9.46	1.442	41.33
V 4	19.84	1.717	nd	15.80	73.55
V 5	20.75	1.363	nd	6.147	52.79
V 6	20.45	0.816	nd	7.419	59.35
V 7	20.2	1.368	nd	4.69	9.445
BPP 1					
BPP 2	21.861	3.149	1.829	4.676	70.96
BPP 5	6.385	2.167	4.47	3.325	23.3
BPP 6	7.155	3.89	2.729	1.242	19.11
BLA39-4	25.6	1.955	4.759	4.419	95.82
Kanaka	24.38	2.108	5.413	2.394	98.53
Akshaya	17.13	0	4.237	0	427.95
Dharasri	17.58	1.539	3.138	2.662	56.67
Dhana	12.76	2.314	5.071	3.221	103.76
Amrutha	13.36	1.822	2.914	1.766	68.5
Anagha	7.49	2.237	1.534	0.818	0
Priyanka	9.86	0.736	0	0	0
Sulabha	5.87	2.429	2.931	0.977	0
NDR 2-1	14.69	2.785	6.442	3.02	0
Jhargram 1	12.994	2.044	nd	0.851	165.86
Bhubaneswar 1	9.623	2.251	3.762	3.51	7.13
CD(5%)	10.183	0.597	2.447	4.194	31.662
SED	5.103	0.299	1.218	2.096	18.321

Table 6.12: Mineral content in the enzyme digest of defatted cashew kernel flour($\mu\text{g}/100\text{mg}$)

Variety	Fe	Cu	Mn	Zn	Se
Ullal 1	0	0.282	0	0	7.089
Ullal 2	0.474	0.879	0	0	5.418
Ullal 3	1.242	0.189	0.171	0.112	9.288
Ullal 4	0.718	0.28	0.06	0	0.815
UN 50	0.34	0.063	0	0	6.653
Chintamani 1	0.30	0	0	1.331	2.719
NRCC Sel-1	1.746	0	0.821	0.875	0
NRCC Sel-2	0.789	0	0.705	0.409	4.297
Bhaskara	1.18	0.543	0.083	0.285	2.363
VRI 1	3.519	0.427	0.866	1.507	2.662
VRI 2	1.225	1.222	0.006	0.546	0
VRI 3	2.736	0.552	0.709	0	0
V 1	0	0.247	0	0	4.662
V 2	0	0.643	0	0	6.623
V 3	0	0.097	0	0	3.337
V 4	0.461	0.247	0	0	2.236
V 5	0.573	0.286	0	0	5.748
V 6	0.439	0.065	0.236	0	4.293
V 7	0.964	1.056	0.458	1.017	3.757
BPP 1	0.942	0.382	0.33	2.896	0
BPP 2	1.606	0.135	0.782	0.889	0
BPP 5	2.45	0.15	1.063	3.232	0
BPP 6	1.425	0.419	1.016	1.895	0
BLA39-4	0.614	0.442	0	0	0
Kanaka	0.934	0.711	0.507	0.819	0
Akshaya	1.676	0.405	0	0	5.64
Dharasri	0.164	0.412	0.441	0	0
Dhana	1.442	1.246	0.562	0	0
Amrutha	0.904	0	0	0	2.207
Anagha	0	0.212	0	0	4.94
Priyanka	0.355	0.616	0	0	0
Sulabha	0.429	0.135	0	0	4.438
NDR 2-1	0.513	0.533	0	0	1.82
Jhargram 1	0.982	0.361	0.258	1.50	0
Bhubaneswar 1	0	0.462	0.306	0	4.093
CD(5%)	0.819	0.206	0.329	0.682	
SEd	0.412	0.104	0.164	0.338	

Table 6.13: Mineral content in the enzyme digest of methanol extracted cashew apple powder ($\mu\text{g}/100\text{mg}$)

Variety	Fe	Cu	Mn	Zn	Se
Ullal 1	0	0.065	0	0	1.66
Ullal 2	0	0.265	0	0	1.55
Ullal 3	0	0.102	0	0	4.02
Ullal 4	0	0.158	0	0.119	0
UN 50	0.474	0.033	0	0.20	0.474
Chintamani 1	0	0.134	0	0.317	4.56
NRCC Sel 1	0	0.41	0.433	0.128	1.923
NRCC Sel 2	0	0.309	0	0.019	6.711
Bhaskara	0	0	0.637	0.094	5.549
VRI 1	0	0.342	0	0.259	5.495
VRI 2	0	0.456	0	0.141	0
VRI 3	0.331	0.057	0	0.386	0
V 1	0	0.103	0.082	0	0
V 2	0.272	0.262	0.195	0	0
V 3	0	0.191	0.149	0	0
V 4	0	0.252	0.225	0.08	0
V 5	0	0.45	0	0	0
V 6	0	0.439	0.145	0	0
V 7	0	0.378	0.657	0.108	3.137
BPP 1	0.594	0.76	0	0.12	0
BPP 2	0.239	0.691	0	0	0
BPP 5	0.206	0.159	0	0.692	0
BPP 6	0.625	0.318	0	0.094	0
BLA39-4	0	2.509	0	0.805	8.39
Kanaka	0	0	0.275	0.054	17.02
Akshaya	0	1.471	0	0.526	2.20
Dharasri	0	1.015	0	0	1.76
Dhana	0	2.025	0	0.166	0
Amrutha	0	1.959	0	0.381	0
Anagha	0	0	0	0.267	1.39
Priyanka	0	1.665	0	0.369	19.24
Sulabha	0	0.731	0	0.211	2.50
NDR 2-1	0	0.38	0.609	0	0
Jhargram 1	0.887	0.259	0	0.014	0
Bhubaneswar 1	0	1.374	0	1.517	13.72
CD(5%)	0.278	0.383	0.129	0.274	2.844
SEd	0.135	0.193	0.063	0.137	1.418

Table 6.14: Mineral content in the enzyme digest of methanol extracted cashew kernel testa ($\mu\text{g}/100\text{mg}$)

Variety	Fe	Cu	Mn	Zn	Se
Ullal 1	0	1.328	0	1.505	11.91
Ullal 2	0	0.34	0	1.987	9.526
Ullal 3	0	0.726	0	0	3.914
Ullal 4	0	0.594	0	0	0
UN 50	0	0.636	0	2.109	3.208
Chintamani 1	0	0.537	0	1.073	5.69
NRCC Sel-1	0	0	0	0	25.78
NRCC Sel-2	0	0	1.74	0	29.47
Bhaskara	0	0	2.63	0	22.9
VRI 1	0	0	0	0	34.98
VRI 2	0	0	0	0	7.71
VRI 3	2.114	0.347	1.106	0	23.67
V 1	0	0	0	0.2	10.19
V 2	2.563	1.644	nd	2.364	7.24
V 3	0	0	0	0	32.09
V 4	0	1.125	nd	1.987	5.58
V 5	1.067	3.236	nd	0	0
V 6	0	2.725	nd	0.707	17.14
V 7	0.68	3.774	nd	0	19.81
BPP 1					
BPP 2	0.674	1.014	1.533	0	59.36
BPP 5	1.079	1.101	1.872	0	7.07
BPP 6	0	0.484	2.264	0	32.93
BLA39-4	0	0.037	1.377	0.57	38.02
Kanaka	0	0.304	1.402	0.362	94.69
Akshaya	0	0.147	0.162	0	0
Dharasri	0	0.393	1.229	2.721	11.41
Dhana	0	0.286	0.26	0.944	94.33
Amrutha	0	0.26	0	0.194	48.25
Anagha	1.059	0.265	0	0.331	0
Priyanka	0	0	0	0.916	0
Sulabha	1.835	0.234	0	0	0
NDR 2-1	8.135	1.335	0	2.761	0
Jhargram 1	0	2.278	0	0	137.24
Bhubaneswar 1	0	0.683	0.41	0	4.76
CD(5%)	1.227	0.414	0.626	0.743	9.187
SED	0.598	0.208	0.309	0.369	4.617

Table 6.15: Variability of mineral content in acid and enzyme digest of defatted cashew kernel flour, methanol extracted cashew apple powder and cashew kernel testa of released varieties (n=3)

Digest	Flour	Variability of mineral content ($\mu\text{g}/100 \text{ mg}$)				
		Fe	Cu	Mn	Zn	Se
Acid	Defatted cashew kernel flour	0.81 - 15.65	0.63 - 3.36	0.41 - 2.19	1.72 - 21.77	0 - 11.51
	Methanol extracted cashew apple powder	2.61 - 126.43	0.55 - 2.84	0.62 - 5.01	0 - 6.03	0 - 32.88
	Methanol extracted cashew kernel testa	7.49 - 71.97	0 - 4.32	0 - 9.76	0 - 24.47	0 - 427.95
Enzyme	Defatted cashew kernel flour	0 - 3.52	0 - 1.25	0 - 1.06	0 - 3.23	0 - 9.29
	Methanol extracted cashew apple powder	0 - 0.89	0 - 2.51	0 - 0.66	0 - 1.52	0 - 19.24
	Methanol extracted cashew kernel testa	0 - 8.13	0 - 3.77	0 - 2.63	0 - 2.76	0 - 137.24

Table 6.16: Variability in per cent bioavailability of minerals in defatted cashew kernel flour, methanol extracted cashew apple powder and cashew kernel testa of released varieties (n=4)

Flour	Fe	Cu	Mn	Zn	Se
Defatted cashew kernel flour	0 - 58.1	0 - 76.4	0 - 80.9	0 - 66.3	0 - 100
Methanol extracted cashew apple powder	0 - 9.6	0 - 100	0 - 100	0 - 72.0	0 - 100
Methanol extracted cashew kernel testa	0 - 100	0 - 100	0 - 83.8	0 - 100	0 - 100

Table 6.17: Number of varieties showing nil % bioavailability of minerals

Minerals	Defatted cashew kernel flour	Methanol extracted cashew apple powder	Methanol extracted cashew kernel testa
Fe	6	27	23
Cu	4	3	10
Mn	16	25	22
Zn	21	12	19
Se	16	4	7

Table 6.18: Varieties showing nil % bioavailability of different minerals in all the three flours namely, defatted cashew kernel flour, methanol extracted cashew apple powder and kernel testa

Minerals	Varieties
Fe	Ullal-1, V-1, V-3
Cu	Nil
Mn	Ullal-1, Ullal-2, UN-50, Chintamani-1, V-5, Amrutha, Anagha, Priyanka, Sulabha
Zn	V-3, V-5
Se	Ullal-4

6.4.4 Conclusion

Bioavailability of Fe, Cu, Zn, Mn and Se in defatted cashew kernel flour, methanol extracted cashew apple powder and cashew kernel testa of released varieties varied with respect to minerals and

varieties. Variety V-7 exhibited better per cent bioavailability of minerals in all the three flours analysed.

6.4.5 Publication

Nagaraja, K.V. 2010. Bioavailability of minerals in cashew. *J. Plantation Crops* (Accepted)



**EDUCATION
TRAINING
GENERAL
MISCELLANEOUS
INFORMATION**

7. EDUCATION AND TRAINING

- A training programme on "Softwood grafting technique in cashew (SGTC)" was organized at this Directorate during 20-21 September 2009. Participants from Shree Kshethra Dharmasthala Rural Development Programme (SKDRDP) attended the programme.
- A special training programme on "Cashew Production Technology" was organized at this Directorate during 2-4 December, 2009 for the officials of Department of Horticulture, Andhra Pradesh.
- A training programme on "Pruning in Cashew and Composting of Recyclable Cashew Biomass" was organized for the officials of BAIF Research and Development (DRUVA-Gujarat and MITTRA - Maharashtra) during 16-18 December, 2009. A total of 16 officials participated and they were intensively trained on these lines.
- A refresher course on "Cashew Production Technology" was organized during 20-22 January, 2010 for participants from BAIF Research and Development (DRUVA-Gujarat); Department of Forest, Orissa and Department of Agriculture, Assam.
- Four training programme on "Cashew Processing" was conducted benefiting 75 Women from Kerala State belonging to Kudumbashree, Kasaragod and Agricultural Technology Management Agency (ATMA), Kannur.
- One day training programme on "Utilization of Cashew Apple" was organised on 10th July 2009.

8. LINKAGES / COLLABORATION

Name of the organization	Type of collaboration
Indian Institute of Horticultural Research, Bangalore.	Bio - Systematics of tea mosquito bug <i>Helopeltis antonii</i> Signoret under net work project "Out Reach Programme on Sucking Pests of Horticultural Crops"
SKDRDP, Dharmasthala Manaje Vyavasaya Sahakari Seva Society, Kamashile Nagarika Seva Trust, Guruvayanakere	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, Kollam.	Insecticide residue analysis
Department of Horticulture, Karnataka Karnataka Cashew Manufacturer's Association, Mangalore. Horticultural Research Station, Ullal, Mangalore.	Farmers' training programmes

9. AICRP-CASHEW CENTRES

Headquarters

The Director
 Directorate of Cashew Research
 (Formerly National Research Centre for Cashew)
 Puttur - 574 202
 Dakshina Kannada
 Karnataka
 Phone : 08251231530, (0); 233490 (R), 230992 (R)
 EPBX: 08251-230902,236490
 Fax: 08251- 234350
 E-mail: dircajures86@yahoo.com
dircajures@rediffmail.com
dircajures@gmail.com
 Website: <http://www.cashew.res.in>

AICRP – Cashew Centres

1. Cashew Research Station, (Andhra Pradesh Horticultural University), Bapatla 522 101, Guntur Dist., Andhra Pradesh.
 Phone: 08643-225304
 E-mail: sscrs@sancharnet.in
2. Cashew Research Station, Department of Horticulture, (Orissa University of Agriculture and Technology), Bhubaneswar 751 003, Orissa.
 Phone : 0674-2395383
 Fax : 0674-2397780
 E-mail : aicrpcashew_bbsr@yahoo.co.in
3. Agricultural Research Station, (University of Agricultural Sciences), Chintamani 563 125, Chickballapur District, Karnataka.
 Phone : 08154- 250056/290553
 Fax : 08154-251 046
 E-mail : reddy cashew @yahoo.com
4. S.G. College of Agriculture and Research Station, (Indira Gandhi Krishi Vishwa Vidyalaya), Jagdalpur 494 005, Kumharawand, Bastar District, Chhattisgarh
 Phone : 07782229150, 229360
 Fax : 07782-229360
 E-mail : zars_igau@rediffmail.com
5. Regional Research Station, (Bidhan Chandra Krishi Viswa Vidyalaya), Jhargram Farm, PO Jhargram - 721 507, Midnapore (West) District, West Bengal.
 Phone : 03221-205500
 E-mail : poduval_mini1971@rediffmail.com

6. Cashew Research Station (Kerala Agricultural University), Madakkathara 680651, Thrissur Dist., Kerala.
 Phone No. and Fax: 0487-2370339
 E-mail: kaucaju@rediffmail.com
7. Regional Agricultural Research Station, (Kerala Agricultural University), Pilicode 671 353, Kasaragod District, Kerala.
 Phone : 0467-2260632 ,2260450
 Fax : 0467-2260554
 E-mail : rars_pil@kau.in
8. Regional Fruit Research Station, (Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth), Vengurle 416 516, Sindhudurg District, Maharashtra
 Telefax: 02366-262234
 Phone : 262693, 263 275 (Farm)
 E-mail: rfrs@sancharnet.in
9. Regional Research Station, (Tamil Nadu Agricultural University), Vridhachalam 606 001, Cuddalore District, Tamil Nadu.
 Phone : 04143- 238231
 Fax : 04143-238120
 E-mail : arsvri@tnau.ac.in, rrsvri@tnau.ac.in

New Centres

10. Agricultural Experimental Station, (Navsari Agricultural University) Paria, Pardi taluk, Valsad District Gujarat
11. Zonal Research Station (Birsa Agricultural University) Darisai, P.O. Barakurshi Eastsinghbhum District Jharkhand - 832 304

Co-operating Centres

1. KRC College of Horticulture, Arabhavi - 591 310, Gokak Taluk, Belgaum District, Karnataka
 Phone : 08332- 284502 (O)
2. ICAR Research Complex for Goa, Ela, Old Goa, Goa
 Phone : 0832-2284677(O)
 E-mail: director@icargoa.res.in
3. ICAR Research Complex for NEH Region, Barapani - 793 103 Meghalaya
 Phone : 0364-2570257(O)
 E-mail: director@icarneh.ernet.in

10. PUBLICATIONS

10.1 Research Publication

Nayak, M.G. and Swamy, K.R.M. 2010. Studies on the effect of Paclobutrazol on growth and yield of cashew (*Anacardium occidentale* L.). *Journal of Plantation Crops*. 38(1):72-74.

Raviprasad, T.N., Bhat, P.S and Sundararaju, D. 2009. Integrated pest management approaches to minimize incidence of cashew stem and root borers (*Plocaederus* spp). *Journal of Plantation Crops*. 37(3) 185:189.

Venkattakumar, V., Yadukumar, N., Nayak, M.G. and Bhat, P.S. 2008. Status of cashew cultivation in Andhra Pradesh - A diagnostic study and recommendations. *Journal of Extension Education* 20 (1-4): 4104-4110.

Venkattakumar, Bhat, P.S. and Nayak, M.G. 2009. Effectiveness of training programme on cashew production technology. *Journal of Extension Education* 21 (1): 4175- 4179.

Yadukumar, N., Rejani, R. and Prabhakar, B. 2009. Fertigation for efficient water and nutrient management in high density cashew plantation. *Journal of Plantation Crops*, 37(2): 102-110.

10.2 Papers presented in Symposia / Workshop / Seminar

Balasubramanian, D. 2010. Present status and future prospects of Cashewnut processing with special emphasis on 'Farm level Cashewnut Processing'; **In:** Inter State Horticultural show organized by National Horticultural Board, GOI at Lalbagh, Bangalore during 9 - 12 October, 2009.

Balasubramanian, D. 2010. Commercialization of technologies developed at ITMC, DCR and its annual expenditure **In:** Meeting cum Workshop conducted by Zonal Technology Management Centre and Business Plan Development Unit (ZTMC - BPDU), Central Institute of Fisheries Technology (CIFT), Cochin during 12 - 13 March, 2010.

Bhat, M.G. 2009. Strategic solutions to improve cashew production on 3rd July 2009. **In:** Biospectrum 2009 - International Symposium on Second Green Revolution: Priorities, Programmes, Social and Ethical issue at Rajiv Gandhi Centre for Biotechnology, Thiruvananthapuram organized by Mar Athanasios College for Advanced Studies in association with Rajiv Gandhi Centre for Biotechnology, Trivandrum held

during 2-4 July 2009. Souvenir and Abstracts P 37-38.

Bhat, M.G. 2009. Enhancing productivity and profitability of cashew. **In:** National Seminar on Enhancing Agricultural Productivity and Profitability at CMFRI, Kochi held during 29-30, August 2009.

Bhat, M.G. and Nayak, M.G. 2010. Production of quality planting material in cashew. **In:** National Conference on Production of Quality Seeds and Planting Material - Health Management in Horticultural Crops. Organised by Society for Promotion of Horticulture at New Delhi during 11-14 March 2010 - Abstracts P 217 (TS 12 : 0-3).

Bhat, M.G., Yadukumar, N., Nagaraja, K.V. and Nayak, M.G. 2009. Current Status of cashew research and technology in India. **In:** National Seminar on Cashew Development in India - Enhancement of Production and Productivity organised by DCCD at Bhubaneswar during 2 - 4 November 2009. Souvenir pp 8-18.

Bhat, P.S. and Raviprasad, T.N. 2009 "Status of insect pests of cashew and strategies for their management". **In:** Meeting of Entomologists of ICAR Institutes of Horticulture Division arranged at Central Institute of Sub-tropical Horticulture, Lucknow during 10 - 11 June 2009.

Bhat, P.S. and Raviprasad, T.N. 2009 Management of pests of cashew **In:** Meeting in State level seminar on "Technologies of Cashew Production" at Shimoga on 20th June 2009 organized jointly by and Academy for Sustainable Development (R), Shimoga, Zonal Agricultural Research Station, Shimoga and Krishi Vignana Kendra, Shimoga. on 20th June 2009.

Bhat, P.S. and Raviprasad, T.N. 2009 Pest Management in Cashew **In:** Workshop on "Hilly land Development with Special Reference to Cashew nut at Diglipur, Andaman and Nicobar Islands" at Diglipur, Andaman and Nicobar Islands during 17-19 November 2009.

Nayak, M. G. 2009 Varieties and pruning in cashew **In:** Workshop on "Hilly land Development with Special Reference to Cashew nut at Diglipur, Andaman and Nicobar Islands" at Diglipur, Andaman and Nicobar Islands during 17-19 November 2009.

Nayak, M.G. 2009 Varieties and pruning in cashew. **In:** Meeting in State level seminar on "Technologies

of Cashew Production" at Shimoga on 20th June 2009 organized jointly by and Academy for Sustainable Development (R), Shimoga, Zonal Agricultural Research Station, Shimoga and Krishi Vignana Kendra, Shimoga on 20th June 2009.

Nayak, M.G. 2009 Quality Planting material in cashew. **In:** National Seminar on Cashew Development in India - Enhancement of Production and Productivity organised by DCCD at Bhubaneswar during 2-3 November 2009.

Nayak, M.G. Adiga J.D. and Meena RK. 2009. Importance of Quality Planting Material in Cashew. **In:** 7th National Seminar on "Cashew Development in India- Enhancement of Production and Productivity", conducted at Bhubaneswar, Orissa during 2 - 4 November, 2009.

Nayak, M.G. and Bhat M.G. 2010. Elite planting material generation – a key to achieve targeted Productivity in Cashew. Presented as Poster paper **In:** National Conference on Production of Quality Seeds and Planting Material - Health Management in Horticultural Crops. Organised by Society for Promotion of Horticulture at New Delhi during 11-14 March 2010 - Abstracts P 231 (TS 12: P8).

Yadukumar, N., Rejanir, R. and Bhat, M.G. 2009. Scope for adoption of soil and water management techniques to increase cashew yields in Andaman and Nicobar Islands. **In:** National Workshop cum seminar on status and future strategies for Horticultural development in Andaman and Nicobar Islands. Central Agricultural Research Institute, Portblair, 23-25 January, 2010.

10.3 Book Chapter

Nayak, M.G. and Bhat M.G. 2009. Canopy Management and Rejuvenation in Cashew. A chapter published in book on "Canopy Management in Fruit Crops" edited by Gorakh Singh - Horticulture Commissioner, Department of Agriculture and Co-operation, Ministry of Agriculture, Govt. of India, New Delhi - 110 011. pp 21-26.

10.4 Technical Reports / Bulletins / Compendia

Directorate of Cashew Research . 2009. Annual Report 2008-09, Puttur, Karnataka, 62 pp.

Directorate of Cashew Research. 2009. Research Highlights. 2008-09, 20pp.

Directorate of Cashew Research. 2009. Cashew News, Newsletter. Vol. 14 (1), Jan-Jun 2009, Puttur, Karnataka. 8 pp.

Directorate of Cashew Research. 2009. Cashew News, Newsletter. Vol. 14 (2), Jul - Dec 2009, Puttur, Karnataka. 12 pp.

10.5 Extension bulletins / pamphlets

Balasubramanian, D and Sreekanth P. D. 2009. Processing and Value addition of Cashew apple. DCR Leaflet ,4pp.

Nayak, M.G., and Adiga, J. D., 2010. Training and pruning in Cashew (*Geru gidagala savaruvike mattu aakaara koduvike*) (Kannada). Directorate of Cashew Research Extension Handout (Revised),6pp.

Nayak M.G. Bhat P.S., Raviprasad T.N. and Adiga, J.D. 2010. Rejuvenation of Cashew trees (*Gerumaragala Punashchetana*) (Kannada). DCR Technical Bulletin . 6pp (Revised).

Yadukumar, N. Nayak M.G. Bhat P.S. and Adiga, J.D. 2010. Improved cashew cultivation (*Sudhaarita Geru Besaaya*) (Kannada). DCR Technical Bulletin . 6pp (Revised).

Yadukumar, N., Bhat P.S. and Adiga, J.D. 2010. High density planting system and cultivation in cashew (*Geru beleyalli Ghana saandra besaaya*) (Kannada), DCR Technical Bulletin . 6pp (Revised).

10.6 Technical bulletins

Bhat P.S. and Raviprasad, T.N. 2010. Tea mosquito bug and its management in cashew DCR Technical Bulletin. 12 pp (English)-(Published by Bhat , M.G., Director).

Bhat P.S. and Raviprasad, T.N. 2010. Tea mosquito bug and its management in cashew (*Gerinalli chaha solleya havali mattu adara nirvahane*) DCR Technical Bulletin. 12 pp (Kannada) - (Published by Bhat , M.G., Director).

Raviprasad, T.N. and Bhat P.S. 2010. Cashew Stem and Root Borer - A major pest of cashew. DCR Technical Bulletin. 12 pp (English) - (Published by Bhat , M.G., Director).

Raviprasad, T.N. and Bhat P.S. 2010. Cashew Stem and Root Borer- A major pest of cashew. DCR Technical Bulletin. 12 pp (Kannada) - (Published by Bhat, M.G., Director).

11. LIST OF ON-GOING RESEARCH PROJECTS

Project No.	Title
I CROP IMPROVEMENT	
1.1	Collection, conservation, cataloguing and evaluation of cashew germplasm (M.G. Nayak, M.G. Bhat, Ramkesh Meena and P.S. Bhat).
1.2	Genetic improvement of cashew for yield and quality traits (J.D. Adiga, M. G. Nayak, Ramkesh Meena and M.G. Bhat).
1.7	Molecular characterization of cashew germplasm (Thimmappaiah)
DBT	Identification of molecular markers linked to economic characters in cashew (Thimmappaiah).
II CROP MANAGEMENT	
2.2(b)	Nutrient requirement and pruning trials in high density cashew plantations (N.Yadukumar).
2.8	Efficacy of soil and water conservation with organic and inorganic manuring in cashew garden grown in slope areas (R. Rejani and N. Yadukumar).
2.11	Performance of high yielding varieties of cashew in different high density planting (N.Yadukumar and J.D. Adiga).
2.12	Rejuvenation of trees of high density cashew orchards through canopy management (N.Yadukumar and 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 and N. Yadukumar).
2.15	Root stock studies in cashew (J.D.Adiga and M.G.Nayak).
Obser. Trial	Effect of foliar application of nutrients on growth, fruit set, yield and nut quality of cashew (N. Yadukumar).
2.16	Effect of foliar application of nutrients on growth, fruit set, yield and quality of cashew (T.R. Rupa and N.Yadukumar).
2.17	Maximization of yield in irrigated cashew and sustaining soil productivity through integrated nutrient management (T.R. Rupa, N. Yadukumar and R. Rejani).
2.18	Effect of Paclobutrazol on growth and yield of cashew (Ramkesh Meena and M.G. Nayak).
III CROP PROTECTION	
3.11	Investigations on insect fauna associate with cashewnut /kernels (TN Raviprasad and P.S. Bhat).
3.13	Studies on sex pheromone of shoot tip caterpillar <i>Hypatima haligramma</i> M. (Gelichiidae: Lepidoptera) (D.Sundararaju and 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)
Paid up Trial	Evaluation of newer insecticides against tea mosquito bug <i>Helopeltis antonii</i> Sig (P.S.Bhat).
Obsv. trial	Evaluation of synthetic fungicides against flowering diseases of cashew (P.S.Bhat)

IV POST-HARVEST TECHNOLOGY

- 4.10 Assessment of bio availability of minerals in cashew (K.V. Nagaraja).
- 4.11 Design, development of artificial dryer for raw cashew nuts (D. Balasubramanian).
- 4.12 Studies on alternate energy utilization of cashew nut shell cake (D. Balasubramanian and Sandeep Gadgil).
- 4.13 Design, development and evaluation of solar tunnel dryer for cashew apple (D. Balasubramanian).
- 4.14 Development of compact type drum roasting machine for raw cashew nuts (D. Balasubramanian and Deshpande, S.D.)
- Obsv. trial Design, development and performance of online detection of spoiled in - shell cashew nuts (D. Balasubramanian).
- NAIP Value chain in cashew for export and domestic market (D. Balasubramanian)

V TRANSFER OF TECHNOLOGY & COMPUTER APPLICATION

- 5.1 Transfer of technology programme in cashew (M.G. Nayak, P.S. Bhat and N.Yadukumar).
- 6.2 Computer application in cashew (P.D. Sreekanth).
- 6.3 Database for cashew germplasm (P.D. Sreekanth).

12. IMPORTANT MEETINGS AND SIGNIFICANT DECISIONS

12.1 Research Advisory Committee

Prof. D.P. Ray, Vice Chancellor Orissa University of Agriculture and Technology Bhubaneswar 751 003, Orissa	Chairman
Dr. I. Irulappan, Former Dean (Horticulture) 28, Abhirami Nagar, Narayanapuram Ist Main Road, Narayanapuram West, Madurai 625 014, Tamil Nadu	Member
Dr. M.N. Khare, Ex-Dean, JNKVV, Jabalpur (MP) 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 Kunnukuzhi, Thiruvananthapuram, Kerala	Non Official 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	Non Official Member
Dr. M.G. Bhat, Director Directorate of Cashew Research Puttur, Karnataka-574 202	Member
Dr. M.G. Nayak Principal Scientist (Horticulture) Directorate of Cashew Research, Puttur 574 202	Member-Secretary

Composition of V RAC is w.e.f. 8.12.2008 for three years.

The first meeting of the Fifth RAC (13th meeting) of the Directorate was held on during 8th June 2009 under the Chairmanship of Prof. D.P. Ray, Vice Chancellor, Orissa University of Agriculture and Technology,

Bhubaneswar 751 003, Orissa. Dr. S. Rajan, Dr. M.M. Khare, Dr. P.M. Salimath, Dr. Narendra Kumar and Dr. P.M. Haldankar participated in the meeting. The progress made under the research projects was discussed in the meeting.

12.2. Institute Management Committee

(Upto 10-02-2010)

Name and Address	Status
Dr. MG Bhat, Director, DCR, Puttur - 574202, DK District, Karnataka. Ph: 08251-231530, 230902 (O), 230992 (R)	Chairman
Dr. S. Rajan Assistant Director General (Hort-I, ICAR, Krishi Anusandhan Bhavan-II, New Delhi-110 012 011-25842467 (O)	Member
The Joint Director of Horticulture, (Plantation Crops & Plant Protection), Lalbagh, Bangalore-560 004, Karnataka	Member
Dr. J. Venkatesha, Director of Instruction (Hort), Horticulture College, Mudigere -577 132, Chickmagalore, District. Karnataka 08263-228022 (O); 08263-228014 (R), Mobile: 9449866912	Member
Senior Finance & Accounts Officer, Central Plantation Crops Research Institute, Kudlu, Kasaragodu - 671 124 , Kerala	Member
Dr. D. Balasimha, Head, CPCRI Regional Station, Vittal-574243, DK district, Karnataka. 08255-265289 (O); 08255-239244 (R)	Member
Dr. K.V.Nagaraja, Principal Scientist (Biochemistry), DCR, Puttur - 574202, DK District, Karnataka, Ph: 08251-230902	Member
Dr. Thimmappiah, Principal Scientist (Genetics & Cytogenetics), DCR, Puttur - 574202, DK District, Karnataka Ph: 08251-230902	Member

Dr. (Mrs.) R. Rejani Scientist (Soil & Water conservation Engineering), DCR, Puttur- 574202, DK District, Karnataka Ph: 08251-230902	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. Mobile: 09421809721 / 09423295550	Member
Sri M.Narayana Bhat, Rtd. Bank Manager Noojibailu House, Manchi Post:, Buntwal Taluk, DK District, Karnataka. 08255 - 276208	Member
Asst. Administrative Officer, DCR, Puttur- 574202, DK District, Karnataka Ph: 08251-230902,236490	Member

(From 11-02-2010)

Name and Address	Status
Dr. M.G. Bhat, Director, DCR, Puttur - 574202, DK District, Karnataka. Ph: 08251-231530, 230902 (O), 230992 (R)	Chairman
Dr. S. Rajan, Assistant Director General (Hort-I, ICAR, Krishi Anusandhan Bhavan-II, New Delhi-110 012 011-25842467 (O)	Member
Dr. P. Shivarama Bhat, Principal Scientist (Agricultural Entomology), Directorate of Cashew Research, Puttur- 574 202, Dakshina Kannada, Karnataka.	Member
Dr. T.R. Rupa, Principal Scientist (Soil Science-Soil Physics & Soil & Water Conservation), Directorate of Cashew Research, Puttur- 574 202, Dakshina Kannada, Karnataka	Member
Dr. K.S. Ananda, Principal Scientist, Central Plantation Crops Research Institute, Regional Station, Vittal-574 243, Kerala.	Member
Dr. S. Arulraj, Project Coordinator (Palms), Central Plantation Crops Research Institute, Kudlu, Kasaragodu- 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. Mobile: 09421809721 / 09423295550	Member
Sri M. Narayana Bhat, Rtd. Bank Manager Noojibailu House, Manchi Post:, Buntwal Taluk, DK District, Karnataka. 08255 - 276208	Member
Asst. Administrative Officer, DCR, Puttur- 574202, DK District, Karnataka Ph: 08251-230902,236490	Member

The Institute Management Committee met twice on 24.10.2009 and 25.03.2010 and reviewed the progress of research project 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 11.02.2010.

12.3 Institute Research Committee (IRC) Meeting

The twenty second Annual Meeting of Institute

Research Committee (IRC) was held during 13-14 July, 2009. Dr. M.G. Bhat, Director, DCR and Chairman of the IRC meeting briefed about the progress made in different research projects. There were different technical sessions viz., "Crop Improvement" chaired by Dr. B.C. Viraktamath, Director, Directorate of Rice Research, Hyderabad, "Crop Management" chaired by Dr. G.S. Prakash, Principal Scientist (Hort.), IIHR, Bangalore, "Crop Protection" chaired by Dr. V.T. Sannaveerappanavar, Professor of Entomology, College

of Agriculture, VC Farm, UAS (Bangalore), Mandya, "Post Harvest Technology" chaired by Dr. M.G. Bhat, Director, DCR, "Transfer of Technology and Computer Application" chaired by Dr. K. Muralidharan, Head,

Division of Social Sciences, CPCRI, Kasaragod. The scientists of the Directorate presented progress made under various projects and technical programme of all the projects was finalized.

12.4 Institute Joint Staff Council (IJSC)

VII IJC	
Official Side	
Dr. M.G. Bhat	Chairman
Dr. J.D.Adiga	Member
Shri. K. Sanjeeva	Member (Upto 31.1.2010)
Shri. K.Jayarama Naik	Member (w.e.f. 1.2.2010)
Shri. H. Ganesha	Member
Dr. (Mrs) R. Rejani	Member- Secretary
Staff Side	
Shri. R.Muthuraju	Member-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.Umanatha Shetty	Member

The IJC met four times at quarterly intervals during the year to discuss about staff welfare activities

12.5 RAJBHASHA

राजभाषा कार्यान्वयन एवं प्रगती

राजभाषा कार्यान्वयन समिति

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

वर्ष 2009-10 में राजभाषा कार्यान्वयन समिति की चार बैठकें आयोजित हुईं। हर बैठक में निदेशालय में हो रही हिन्दी कार्यान्वयन के संबंध में चर्चा किया गया। जरूरी विचारों पर केन्द्र से आए पत्रों एवं सूचना के बारे में भी चर्चा किया गया। जैसा कि हमें वार्षिक कार्यक्रम के अनुसार निश्चित लक्ष्य दिया गया था उन लक्ष्यों के प्राप्ति के लिए की जा रही कार्रवायी 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 जिज्ञाक दूर करने के लिए समय समय पर हिन्दी कार्यशाला का आयोजन किया जा रहा है। सितंबर में आयोजित हुई हिन्दी पखवाडा में हमेशा की तरह कर्मचारी बडे उत्साह से भाग लिये हैं।

पुत्तूर नगर राजभाषा कार्यान्वयन समिति (नराकास)

काजू अनुसंधान निदेशालय, पुत्तूर नगर राजभाषा कार्यान्वयन समिती (नराकास) की संयोजक कार्यालय है। यह निदेशालय पुत्तूर 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 जनेवरी में, पुत्तूर नगरकास की दो अर्धवार्षिक बैठकें आयोजित हुई। इन बैठकों में पुत्तूर और विट्टल के सभी केन्द्र सरकारी कार्यालयों से कार्यालय प्रधान / अधिकारी भाग लिए। हर कार्यालय में हो रही गतिविधियों की समीक्षा करना और उन्हें आगे बढ़ाने के लिए जरूरी सूचना, मार्गदर्शन देना इन बैठकों का उद्देश था। इसी दृष्टी से अनेक विचारों पर चर्चा भी किया गया और निर्णय भी लिया गया।

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

सितंबर 14-28 तक बहुत उत्साहपूर्ण वातावरण में हिन्दी पखवाडा मनाया गया। इस अवसर पर कर्मचारियों और विद्यार्थियों के लिए अनेक प्रतियोगिताओं का आयोजन किया गया। विद्यार्थियों को, हिन्दी सीखने की प्रति प्रेरणा देने के लिए, हिन्दी परीक्षाओं में उत्तम अंक प्राप्त करने के लिए नगद पुरस्कार से सम्मानित किया गया। हिन्दी की प्रसारण को विस्तृत रूप देने की दृष्टी 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।

13. PARTICIPATION IN SYMPOSIA / CONFERENCES / SEMINARS / MEETINGS

Nayak, M.G.	Brainstorming session of genetic resources of Horticultural Crops - Status of collection, conservation evaluation and export, organized at NBPGR, New Delhi.	21 April, 2009.
Bhat, M.G.	Deliberations to formulate Technology Mission on Cashew held under the Chairmanship of Additional Secretary (AB), Ministry of Agriculture, Department of Agriculture and Cooperation, Krishi Bhavan, New Delhi.	
Bhat, P.S.	Meeting of Entomologists of ICAR Institutes of Horticulture Division arranged at Central Institute of Sub- tropical Horticulture, Lucknow.	
Yadukumar, N.	Seminar on "Technologies of Cashew Production" at Shimoga organized jointly by and Academy for Sustainable Development (R), Shimoga, Zonal Agricultural Research Station, Shimoga and Krishi Vignana Kendra, Shimoga.	
Bhat, M.G.	143 rd Board Meeting of Karnataka Cashew Development Corporation (KCDC) at Registered Office of KCDC Ltd., Mangalore.	
Bhat, M.G.	Biospectrum 2009-International Symposium on "Second Green Revolution: Priorities, Programmes, Social and Ethical Issues" at Rajiv Gandhi Centre for Biotechnology, Thiruvananthapuram.	

	organized by Mar Athanasios College for Advanced Studies in association with Rajiv Gandhi Centre for Biotechnology, Trivandrum.	
Bhat, M.G. Nayak, M.G.	National Debate on DUS Testing Procedure for Tropical and Sub - Tropical Plantation Crops at CPCRI, Kasaragod.	10 July, 2009
Bhat, M.G.	ICAR Directors Meet, New Delhi.	16 th July, 2009
Bhat, M.G.	National Meet on Conservation Agriculture and Interface Meeting convened by DDG (NRM) at NAAS Complex, NASC Auditorium, Pusa, New Delhi.	17 July, 2009.
Bhat, M.G.	Panel meeting / Discussion on carbon sequestration in Plantation Crops and trading under Clean Development Mechanism (CDM) at CPCRI, Kasaragod.	4 August, 2009.
Bhat, M.G. Sreekanth, P.D.	Workshop on Information Technology Applications in Horticultural Crops organized at CPRI, Shimla.	24 - 25 August 2009.
Bhat, M.G.	National Seminar on 'Enhancing Agricultural Productivity and Profitability' organized by ICAR at CMFRI, Kochi.	29 - 30 August, 2009.
Bhat, M.G.	Special Interactive Workshop on Administrative and Financial matters for the ICAR Institutes located in Western and Southern Zone organized by ICAR at NAARM, Hyderabad.	10-11 September, 2009.
Bhat, M.G.	144 th Board Meeting of Karnataka Cashew Development Corporation (KCDC) and 31 st Annual General Body Meeting at Registered Office of KCDC Ltd., Mangalore.	23 September, 2009.
Rupa, T.R.	A seminar on Statistical methods for perennial crops - current status and strategies at CPCRI, RS, Vittal (Karnataka).	30-31 October, 2009.
Bhat, M.G. Yadukumar, N Nayak, M.G. Raviprasad, T.N.	National Seminar on Cashew - 2009 "Cashew Development in India - Enhancement of Production and Productivity" organized by Directorate of Cashewnut and Cocoa Development (DCCD), Kochi in association with Orissa State Cashew Development Corporation at Bhubaneswar, Orissa.	2 - 4 November, 2009
Bhat, M.G. Nagaraja, K.V. Yadukumar, N. Nayak, M.G. Bhat, P.S. Rupa, T.R. Raviprasad, T.N. Adiga J.D. Rejani, R.	National Group Meeting of Scientists of AICRP Cashew at Tamil Nadu Agricultural University, Coimbatore.	13-15 November, 2009.
Nagaraja, K.V. Yadukumar, N. Nayak, M.G. Bhat, P.S	Workshop on "Hilly land Development with Special Reference to Cashew nut at Diglipur, Andaman and Nicobar Islands".	17-19 November, 2009.
Bhat, M.G. Nayak, M.G	Interactive meeting on tools and machinery for Development of Horticulture. Jointly organised by IIHR, Bangalore and CPCRI, Kasaragod at CPCRI, Kasaragod.	18-19 December, 2009.

Bhat, M.G.	146 th Board Meeting of Karnataka Cashew Development Corporation (KCDC) at Registered Office of KCDC Ltd., Mangalore.	04 January, 2010.
Bhat, M.G.	Meeting of Horticulture Division, Directors and Project Co-ordinators, New Delhi	2-3 February, 2010.
Nayak, M. G. Balasubramanian, D.	Workshop cum training programme on Cashew Production Technology at Shimoga organized by KVK Shimoga and an NGO, Academy for sustainable Development, Shimoga.	2-4 February, 2010.
Balasubramanian, D.	Special meeting of NAIP on Value Chain on Cashew for Export and Domestic Market conducted by Cashew Export Promotion India (Lab division), Kollam at Karnataka Cashew Manufacturers Association (KCMA), Mangalore.	5 - 6 February, 2010
Rupa, T.R.	National Brainstorming Workshop on Land Resources and its Related Issues at Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Dist. Nadia, West Bengal.	14-17 February, 2010.
Bhat, M.G.	Meeting of Directors of ICAR Institute and Interface meeting with Vice-Chancellor of SAUs.	15-17 February, 2010
Bhat, M.G. Nayak, M.G.	National Conference on Production of Quality Seeds and Planting material - Health Management in Horticultural Crops at NASc Complex, New Delhi.	11-14 March, 2010.
Balasubramanian, D.	Meeting cum Workshop conducted by Zonal Technology Management Centre and Business Plan Development Unit (ZTMC - BPDU), Central Institute of Fisheries Technology (CIFT), Kochi.	12 -13 March, 2010.
Bhat, M.G.	147 th Board Meeting of Karnataka Cashew Development Corporation (KCDC) at Registered Office of KCDC Ltd., Mangalore.	20 March ,2010.
Nayak, M.G.	Biodiversity year inauguration day organized by Science Forum St. Philomenas College, Puttur.	24 March, 2010.
Nayak, M.G.	Seminar on cashew organized by APMC Board, Mysore at Moodabidri.	25 March ,2010.
Balasubramanian, D.	Program on "Production, Processing and Marketing of Cashew" conducted by Regional Agricultural research Station, Pillicode, Kerala.	29 March, 2010.
Nayak, M.G.	Seminar on cashew organized by APMC, Puttur at Puttur.	31 March, 2010.

14. FARMERS' DAY / KRISHI MELA / EXHIBITION / CAMPAIGNS / CONSULTANCY / SPECIAL ASSIGNMENT

Nayak, M.G.	Consultancy visit for guidance on cashew cultivation to the beneficiaries of BAIF Development Research Foundation, Pune (DRUVA in Gujarat and Dadra Nagar Haveli Union Territory and MITTRA in Maharashtra).	6-12 December, 2009.
Nayak, M.G. Seetharama K. Ravishankar Prasad	Exhibition in connection with State Youth Festival "Yuvajana Mela 2009" at Sullia.	26-28 December, 2009.
Nayak, M.G. Ravishankar Prasad	Exhibition in connection with mass media and communication programme of NAIP project at Peruvannamaih, IISR, Calicut.	8-12 February, 2010.
Nayak, M.G. Adiga J.D. Prakash G.Bhat Seetharama K. Ravishankar Prasad	Exhibition in connection with flower and fruit show arranged by Karnataka State Department of Horticulture at Mangalore.	19-23 February, 2010.
Bhat, M.G. Nayak, M.G.	Cashew Day Programme at ARS Ullal, Mangalore.	26 February, 2010.
Director, all Scientists, technical and administrative staff	Annual Cashew Day at Keyyur, Puttur taluk.	4 March, 2010.
Nayak, M.G. Seetharama K. Ravishankar Prasad	Horti Expo organized at NASC Complex, New Delhi in connection with National Conference on Production of Quality Seeds and Planting material - Health Management in Horticultural Crops.	11-14 March, 2010.
Adiga J.D. Lakshmi pathi Ramesh Babu K.V.	Exhibition organized at Indian Institute of Horticultural Research, Bangalore in connection with the NAIP sub - project on Mobilising Mass Media Support for Sharing Agro Information.	26-27 March, 2010.

15. DELEGATION / TRAINING

Sreekanth, P.D.	"Data Mining and GIS for Decision Support in Agricultural Research" at IIM, Lucknow	31 August to 11 September, 2009.
Bhat, P.S.	Course on "Creative writing in Agriculture" at Indian Institute of Mass Communication (IIMC), New Delhi	5-9 October, 2009.
Balasubramanian, D.	Training programme on "To Familiarize with Procurement Related Matters and Financial Management" at National Institute of Animal Nutrition and Physiology (NIANP), Bangalore	6-7 October 2009.
Rupa, T.R.	Training programme on "General Management Programme for Senior Women Scientists" at Administrative Staff College of India, Hyderabad.	23 November - 4 December 2009.
Balasubramanian, D.	Training program on "Management Development Programme" (MDP) and Workshop on "Priority Setting, Monitoring and Evaluation of Agriculture and Livelihood Based Projects" under National Agricultural Innovation Project (NAIP) at National Institute of Rural Development (NIRD), Hyderabad.	30 November - 4 December, 2009.
Sreekanth, P.D.	"Recent Advances in Web Technology for Information Management in Agriculture" at IASRI, New Delhi	16 February - 8 March, 2010.
Nagaraja, K.V.	XXI Training programme on "Emerging Trends in Nutraceuticals and Dietary Supplements". Centre of Advanced Faculty Training in Foods and Nutrition Post Graduate and Research Centre, APAU, Hyderabad	3-23 March, 2010.

16. RADIO TALK / INTERVIEW

P.S. Bhat	Radio talk on "Tea Mosquito Bug in Cashew and it's Management" - Broadcast by All India Radio(AIR), Mangalore.	18 March, 2010
J. D. Adiga	An interview on "Varietal Improvement of Cashew" Broadcast by AIR, Mangalore.	22 March, 2010

17. DISTINGUISHED VISITORS

Dr. L.Krishna Swamy Former Director Directorate of Cashewnut and Cocoa Development Kochi	21-05-2009
Prof. D.P. Ray Vice - Chancellor Orissa University of Agriculture and Technology Bhubaneshwar 751 003 Orissa	08-06-2009
Dr. Akali Sema Director Central Institute of Horticulture, Medzippema, Nagaland	23-06-2009
Dr. P.G. Chengappa Vice-Chancellor University of Agricultural Sciences Gandhi Krishi Vignana Kendra Bangalore, Karnataka	30-10-2009
Dr. V. Tagat Chief General Manager National Bank for Agriculture and Rural Development Bangalore	20-11-2009
Dr. M.M.Pandey Deputy Director General (ICAR) New Delhi	20-12-2010
Dr. Pitam Chandra Director Central Institute of Agricultural Engineering Bhopal, Madhya Pradesh	20-12-2010
Dr. S.P. Dandin Special Officer/Vice-Chancellor University of Horticultural Sciences Bagalkot, Karnataka	5-01-2010

18. PERSONNEL (as on 31-3-2010)

Managerial

Director

Dr. M.G. Bhat

18.1 Scientific

Discipline	Scientist	Scientist (Sr.Scale)	Sr.Scientist	Pr.Scientist	Total (Incl. Vacant Posts)
Agricultural Structures and Process Engg. (ASPE)	—	—	D. Balasubramanian	—	1
Agricultural Entomology	—	—	Vacant T.N.Raviprasad	P.S. Bhat	3(1)
Agril.Extension	Vacant	—	—	—	1(1)
Biochemistry (Pl.Sci.)	—	—	—	KV Nagaraja	1
Biotechnology	—	—	Vacant	—	1(1)
Computer Application	—	PD. Sreekanth	—	—	1
Genetics and Cytogenetics	—	—	Vacant	Thimmappaiah (Gen. & Cytogen.)	2 (1)
Horticulture	Ramkesh Meena*	—	J.D. Adiga Vacant-1 post	M.G. Nayak	4 (1)
Plant Physiology	Vacant	—	—	—	1 (1)
Soil Science	—	—	—	N Yadukumar (Agr)	1
Soil Science - Soil Physics and Water Conservation	—	—	—	T.R. Rupa	1
Soil and Water Consvtn. Engg.	—	R. Rejani	—	—	1
Total	3 (2)	2	7 (4)	6	18 (6)

* On study leave for Ph.D.

Figures in the parantheses indicate no. of vacant posts.

18.2. Technical

Sri. K.Muralikrishna	Farm Superintendent T(7-8)
Sri. P. Adbulla	Farm Superintendent T (7-8)
Sri. R.Arulmony	Tech. Officer (lib.) T (7-8)
Sri. A.Padmanabha Hebbar	Tech. Officer (Elec.) (T-6)
Sri. Prakash G Bhat	Tech. Officer (T-6)
Sri. N.Manikandan	Technical Officer (T-5)
Sri. R. Muthuraju	Technical Officer (Computer) (T-5)
Sri. K. Seetharama	Technical Officer (T-5) (Farm)
Sri. Lakshmipathi	Technical Officer (T-5)
Sri. R. Lakshmisha	Technical Officer (T-5)
Sri. K.V. Ramesh Babu	Technical Officer (T-5)

Sri. A. Poovappa Gowda (T-4), Sri. Ravishankar Prasad, Sri. K. Babu Poojary and Sri. Bejmi Veigus (T-3), and Sri. K. Umanath (T-2), Sri. P. Honappa Naik (T-1).

18.3. Administration

Sri Ganesh	Assistant Finance and Accounts Officer
Sri.K.Sanjeeva	Assistant Administrative Officer (Upto 31-1-2010)
Sri. K. Jayarama Naik	Assistant Administrative Officer (Stores)

Ms. B. Jayashree and Sri. O.G. Varghese (Personal Assistants); Ms. K. Reshma (Jr. Stenographer); Sri. K.M. Lingaraju and Ms. M. Ratna Ranjani (Assistants) Ms. Winne Lobo, Sri. Rosario Mascarenhas (upto 31.12.2009) and Ms. Leela (UDCs); Sri.Uma Shankar and Ms Padmini Kutty (LDCs); Sri. K. Balappa Gowda (Gestetner Operator)

19. MISCELLANEOUS

19.1 Visitors

About 2000 visitors viz., farmers, development department officials were provided knowledge about the research and development activities of DCR, Puttur.

19.2 Consultancies

A team of two scientists visited the cashew orchards established by tribal farmers with guidance from BAIF, Pune (DRUVA in Gujarat and Dadra Nagar Haveli Union Territory and MITTRA in Maharashtra). They studied the situation and conditions of cashew orchards in Dang, Navsari and Valsad districts of South Gujarat, Port of Dadra Nagar Haveli Union Territory and Nasik and Thane districts of Maharashtra and offered consultancy for the improvement of cashew orchards and the production.

19.3 Average weather data (2009-'10)

Month	Maximum Temperature (°C)		Humidity (%)		Rainy days	Rainfall (mm)	Sunshine hours	Evaporation
	Max.	Min.	FN	AN				
Apr. 09	37.8	23.8	89	49	16	38.3	6.2	4.4
May 09	36.6	23.6	93	55	7	159.6	5.8	3.4
Jun. 09	32.8	23.1	96	79	18	360.3	3.1	2.5
Jul. 09	29.9	22.5	96	80	32	1827.9	1.4	1.8
Aug. 09	31.3	22.9	97	80	24	429.5	2.5	2.4
Sep. 09	31.3	22.9	96	86	19	429.6	2.5	2.2
Oct. 09	34.1	22.3	94	62	9	112.7	6.6	3.6
Nov. 09	33.9	21.9	94	71	9	225.6	6.2	3.5
Dec. 09	34.5	20.5	92	65	4	56.6	8.4	3.7
Jan. 10	34.7	18.7	92	60	1	39.0	9.0	4.4
Feb. 10	36.6	19.9	91	51	0	0.0	9.3	4.9
Mar. 10	37.7	23.0	90	46	1	11.0	7.6	5.3

19.4. List of DCR publications

Sl. No.	Publication	Price (Rs.)
1	Cashew Production Technology (Revised)	50.00
2	Softwood grafting and nursery management in cashew	35.00
3	Annotated Bibliography on Cashew (1985-1994)	75.00
4	Catalogue of Minimum Descriptors of Cashew	
	Germplasm accessions - I	165.00
	Germplasm accessions - II	125.00
	Germplasm accessions - III	128.00
5	Status of Cashew Germplasm Collection in India (Booklet)	
6	Compendium of Concluded Research Projects (1986 - 2001)	
7	Sudharitha geru besaya kramagalu (Booklet in Kannada)	15.00
8	Nutritive Value of Cashew (Revised) Brochure	
9	Database on cashew nut processing in India (2003)	100.00
10	Directory of cashew nut processing industries in India (2003)	100.00
11	Process catalogue on development of economically viable on-farm cashew nut 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. Postage extra

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

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

