

# वार्षिक प्रतिवेदन ANNUAL REPORT 2007 - '08



**NATIONAL RESEARCH CENTRE FOR CASHEW**

(Indian Council of Agricultural Research)

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## राष्ट्रीय काजू अनुसंधान केन्द्र

(भारतीय कृषि अनुसंधान परिषद्)

पुत्तूर - 574 202, दक्षिण कन्नड, कर्नाटक

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## प्रस्तावना

सन् 2007 अप्रैल से मार्च 2008 तक की समय में इस केन्द्र का निष्पादन को प्रस्तुत करने के लिए मुझे प्रसन्नता होता है। फसल सुधार, फसल प्रबंधन, फसल संरक्षण, कटाई उपरान्त प्रौद्योगिकी और तकनीकी हस्तांतरण के क्षेत्रों में किये गये प्रगतियों इस प्रतिवेदन में सम्मिलित है। राष्ट्रीय काजू क्षेत्र जीन बैंक (NCFGB) में और तीन एक्सेशनों का रोपण करने से अब तक संरक्षित एक्सेशनों 509 हुआ। H-66, H-68, H-43, H-125 व H-126 जैसे बड़े गुटलीवाली संकरणों 4वीं कटाई में 5.5 कि.ग्रा. उपज देकर तथा 19 कि.ग्रा. / पेड का संचई उपज देकर आशाजनक रहा। कुल 40 श्रेष्ठ काजू किस्मों / श्रेष्ठ काजू सामग्री को 15 SSR प्रैमर जोड़ियों के साथ जाँचा गया जिससे यह पता चला कि उल्लाळ-4 तथा H-32-4 अत्यंत साम्यता दिखाई। साधारण पेड धनत्व फ्लाट से मिली उपज (511 कि.ग्रां.) / हे) से उच्च धनत्व फ्लाटो (416 पेड/हे तथा 500 पेड/हे) का उपज (1093 तथा 1018 कि.ग्रां/हे) सार्थकरूप से अधिक रहा। काजू बगानों में हरा-खाद प्रयोगों में, मिट्टी का सावयव अंगारक का मात्रा (0.98%) व N की मात्रा (186 कि.ग्रां./हे) अन्तराल में ग्लैरीसीडिया उगाया फ्लाटो में सार्थकरूप वृद्धि दिखाया। परागण का मात्रा बढ़ाने से काजू की उत्पादकता काफी बढ़ा सकते हैं। चाय मच्छर (TMB) के विरुद्ध परीक्षित नये कीटनाशकों में फेनप्रोपाथ्रीन (0.02%) शिफारित कीटनाशकों का समानरूप रहा। चरबीनिकालित काजू गरी आटा में, Fe तथा Zn का जीवलभ्यता Mn, Cu तथा Se से कम था। कृषकों तथा विकास विभागों का आफसरो के लिए केन्द्र में काजू उत्पादन प्रौद्योगिकी के विविध आयामों पर प्रशिक्षण कार्यक्रमों आयोजित थे। केन्द्र ने प्रदर्शनो में भाग लिया और प्रमुख किस्मों का कलमनो को उत्पादित किया और बॉटा।

2007-08 का वार्षिक प्रतिवेदन का संकलन में सम्पादकीय समिति का परिश्रमों को मे अभिस्वीकृत करता हूँ।

स्थल : रा. का. अ. के., पुत्तूर  
दिनांक : 5 आगस्त, 2008

एम. गोपालकृष्ण भट्ट  
(एम. गोपालकृष्ण भट्ट)  
निदेशक

## PREFACE

I am happy to present the achievements of the Centre for the period from April 2007 to March 2008. The progress made in the areas of Crop Improvement, Crop Management, Crop Protection, Post-Harvest Technology and Transfer of Technology are covered in this report. Three more accessions were planted in National Cashew Field Gene Bank (NCFGB), bringing the total accessions conserved so far to 509. Bold nut hybrids H-66, H-68, H-43, H-125 and H-126 were promising with more than 5.5 kg yield in 4<sup>th</sup> harvest and cumulative yield of more than 19 kg/tree for 4 harvests. A total of 40 elite varieties /elite material of cashew were screened with 15 pairs of SSR primers and the highest similarity was observed between Ullal-4 and H 32-4. The yield in the high tree density plots (416 and 500 trees/ha) was significantly higher (1093 and 1078 kg/ha) than in normal tree density plot (511 kg/ha). In green manuring studies in cashew plantations, soil organic carbon and N contents increased significantly in the plot where gyricidia was grown in the inter space ( 0.98% and 186 kg N/ha respectively). By enhancing the level of pollination, the productivity of cashew can be enhanced considerably. Among the newer insecticides tested against tea mosquito bug (TMB), fenprothrin (0.02%) was on par with recommended insecticides. In defatted cashew kernel flour, bioavailability of Iron (Fe) and Zinc (Zn) was less compared to Manganese (Mn), Copper (Cu) and Selenium (Se). Training programmes on various aspects of Cashew Production Technology were organized at the Centre for the benefit of the farmers and the officials of the Development Departments. The Centre participated in exhibitions and produced and distributed large number of grafts of elite varieties.

I acknowledge the efforts of the members of the Editorial Committee in compiling the Annual Report 2007-'08.

Place : NRCC, Puttur  
Date : 5<sup>th</sup> August 2008



(M. GOPALAKRISHNA BHAT)  
Director

## कार्यकारी सारांश

प्रस्तुत साल में राष्ट्रीय काजू अनुसंधान केंद्र, पुत्तूर में कुल 27 परियोजनाओं प्रचालित थे, जिसमें एक प्रयोग और दो DBT परियोजनाओं शामिल थे। राष्ट्रीय काजू क्षेत्रीय जीन बैंक (NCFGB) को तीन एक्सशनो जोड़ा गया जिससे अब तक संरक्षित एक्समनो का कुल संख्या 509 हुआ। H-66, H-68, H-43 जैसे संकरो (सभी NRCC-SEL-2x भूतनाथ का क्रस कांविनेशन) तथा H-125, H-126 (दोनों NRCC-SEL-2x भेडसी का क्रस कांविनेशन) आशाजनक पाया गया, जिनमें 4वीं कटाई में 5.5 कि.ग्रा. से अधिक उपज, और 19 कि.ग्रा. का संचई उब्ज (4 कटाई में) तथा 10 ग्रां. से अधिक औसत गुटली वजन पाया गया। कुल 40 श्रेष्ठ काजू किस्मों को 15 SSR प्रमर जोडियो के साथ जाँचा गया जिससे यह पता चला कि उल्लाळ-4 तथा H-32-4 में अत्यंत साम्यता है। छोटा गुटली गात्र के लिए एक “पुटेटीव” मार्कर जननद्रव्य राशी में पहचाना गया।

साधारण पेड धनत्व प्लाट से मिली उपज (511 कि.ग्रा./हे) से उच्छ धनत्व प्लाटो (416 व 500 पेड/हे) का उपज (1093 से 1078 कि.ग्रा./हे) सार्थकरूप से अधिक रहा। उप प्लाटो में (उर्वर मात्रा), जब उर्वर स्तर M1-75 कि.ग्रा./हे N, तथा 25 कि.ग्रा./हे P<sub>2</sub>O<sub>5</sub> व K<sub>2</sub>O प्रत्येक (961 कि.ग्रां./हे) से M1-225 कि.ग्रां/हे N तथा 75 कि.ग्रां./हे P<sub>2</sub>O<sub>5</sub> व K<sub>2</sub>O प्रत्येक (835 कि.ग्रां./हे) तक बढ़ा, उपज सार्थकरूप से कम हुआ। काजू बगानों के हरा खाद प्रयोगों में, मिट्टी में सावयव अंगारक का मात्रा (0.98%) व N मात्रा (186 कि.ग्रां./हे), अन्तराल में ग्लैरिसीडिया उगाया प्लाटो में सार्थकरूप वृद्धि दिखाया। उपयोगी सूक्ष्मजीवाणुओ ग्लैरिसीडिया (229 µg/c/g) तथा शण (261 µg/c/g) प्लाटो

में सूक्ष्मजीवाणु जीवमात्रा की विजार में अधिक रहा।

ट्रैबोलिपम कास्टेनियम, एफीस्टीया कॉटेल्ला, औरैजेफिलस सूरिनामेन्सिस और रैजोपरथा डोमिनिका जैसे उग्राण कीटो देश की विविध भागों में निरीक्षण किये गये काजू संस्करण एक्को में पाया गया। गोदामों में संग्रहित “रिजेक्ट्स” तथा “टेस्टा” में ट्रैबोलिपम कास्टेनियम का उपस्थिति सामान्यतः पाया गया। मानसून काल में (जुलाई से अक्टोबर तक) उडीसा तथा पलासा (आ.प्र.) में एफीस्टीया कॉटेल्ला का बाधा अधिक होना प्रतिवेदित था।

काजू में मधु मक्खियों का आगमन दर का अवलोकनो से व्यक्त हुआ कि माधु मक्खियो ने नर और द्विलिंग पुष्पो को सिर्फ मकरंद संग्रहण के लिए जा रहे थे। एपीस-एतर प्रभेदो (हयालिक्टिड् तथा आन्तोफोरिड्) ने प्रति पुष्प में मंकरंद तथा पराग संग्रहण के लिये अत्यधिक समय (13 सेकेंड तक) बिताया। परागण का मात्रा बढ़ाने से काजू की उत्पादकता काफी बढ़ा सकते हैं। काजू सेबो में λ-सैहालोथ्रीन का अवशेष उपचार के 15 दिन के अन्दर 0.2 ppm का अत्यधिक अवशेष सीमा (MRL) की नीचे गिरा, जब कार्वारिल का अवशेष 21 दिनों के भीतर, 0.5 ppm का (MRL) की नीचे गिरा। चाय मच्छर (TMB) के विरुद्ध परीक्षित नये कीटनाशको में फेन्प्रोपाथ्रीन (0.02%) शिफारित कीटनाशक -सैहालोथ्रीन (0.003%) से समानरूप रहा।

विमोचित किस्मो का चरबीनिकालित काजू गरी आटा में खनिजे का जीवलभ्यता सार्थकरूप से विभिन्नता दिखाई। Mn, Cu तथा Se की तुलना में Fe तथा Zn अत्यंत

जीवलभ्यता दिखाई काजू गुटली सुखाने के लिए “ड्रैअर” विन्यास और विकसन के लिये प्रयत्न किया गया है। बिना कुछ संयोजन काजू छिलको का सांद्रीकरण कष्टसाध्य रहा।

इस साल में काजू मृदुकांड कलमन तथा नर्सरी प्रबंधन, काजू में छॉटन तथा परिचक्रित काजू जीवराशी का काँपोस्टिंग, काजू उत्पादन प्रौद्योगिकी तथा काजू सेव उपयोग की बारे में प्रशिक्षण कार्यक्रमो आयोजित थे। लखनऊ का

CISH में, नई दिल्ली का “फुड एक्स्पो 2001” में तथा अन्तर्राष्ट्रीय वागवानी एक्स्पो-2008, और कासरगोड में आयोजित किसान मेला में केंद्र ने भाग लिया था। केंद्र ने लगभग 2.5 लाख अधिक उपज देनेवाली किस्मो का उत्पादन किया और बाँटा।

केंद्र की परिचालित तथा संपूर्णित परियोजनाओ की परिणामों का सारांश इस वार्षिक प्रतिवेदन में प्रस्तुत है।



## EXECUTIVE SUMMARY

During the year, a total of 27 projects including one ad-hoc project, one paid up trial, two DBT projects were in operation at National Research Centre for Cashew, Puttur. Three germplasm accessions collected were added to National Cashew Field Gene Bank (NCFGB) raising the total germplasm conserved so far to 509. Hybrids H-66, H-68, H-43 (all are cross combination of NRCC Sel-2 and Bhuthnath-II) and hybrids H-125 and H-126 (both are of cross combination of NRCC Sel-2 x Bhedasi) were promising with more than 5.5 kg yield in 4<sup>th</sup> harvest and cumulative yield of more than 19 kg /tree (for 4 harvests) with the average nut size of more than 10 g. A total of 40 elite material of cashew screened with 15 pairs of SSR primers and the highest similarity was observed between Ullal-4 and H 32-4. Among the varieties, VRI-3 and V-6 were most divergent. A putative marker for small nut size was identified in germplasm bulks.

The yield in the high tree density plots (416 and 500 trees/ha) was significantly higher (1093 and 1078 kg/ha) than in normal tree density plot (511 kg/ha). Among the subplots (manurial doses), the yield decreased significantly as fertilizer level increased from M1- 75 kg N, 25 kg each of P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O / ha (961 kg/ha) to M3 -225 kg N, 75 kg each of P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O/ha (835 kg/ha). In green manuring studies in cashew plantations, soil organic carbon and N contents increased significantly in the plot where glyricidia was grown in the inter space (0.98 % and 186 kg N/ha respectively). Beneficial micro organisms in terms of microbial biomass produced was also high in glyricidia (229 µg c/g) and sunhemp (261 µg c/g) plots.

*Tribolium castaneum*, *Ephestia cautella*, *Oryzaephilus surinamensis* and *Rhyzopertha dominica* were the common storage insect pests noticed in the cashew processing units visited in the different parts of the country. Occurrence of *Tribolium castaneum* was most commonly noticed on rejects and testa stored in the warehouses. The infestation by *Ephestia cautella* was reportedly higher during the monsoon months (July to October) at Orissa and Palasa (A.P).

The observation on visitation rate of honey bees on cashew revealed that, the honey bees visited both male and bisexual flowers, only for the collection of the nectar. The non-*Apis* species (halictids and anthophorids) spent maximum time (up to 13 seconds) per flower in collection of nectar and pollen. By enhancing the level of pollination, the productivity of cashew can be enhanced considerably.

The residues of λ- cyhalothrin in cashew apples fell below the maximum residue limit (MRL) of 0.2 ppm within 15 days of treatment while the residues of carbaryl fell below MRL of 0.5 ppm within 21 days. Among the newer insecticides tested against tea mosquito bug (TMB), the damage rating in fenpropathrin (0.02%) was on par with the recommended insecticides λ- cyhalothrin (0.003%).

Bioavailability of minerals in defatted cashew kernel flour of released varieties exhibited significant variation. Iron (Fe) and zinc(Zn) are most bioavailable compared to Manganese (Mn), copper (Cu) and Selenium (Se). Attempts have been made to design and develop artificial dryer for cashew nuts. Densification of cashew shells without any addition

was found to be difficult.

During the year, training programmes on softwood grafting of cashew and nursery management, pruning in cashew and composting of recyclable biomass, cashew production technology and cashew apple utilization were organized. The Centre participated in exhibitions at CISH, Lucknow, Food

Expo 2007 at New Delhi, International Horticultural Expo 2008 at New Delhi and Kisan Mela at Kasaragod. The Centre has produced and distributed about 2.5 lakh grafts of high yielding varieties.

The summary of results of the ongoing and concluded research projects of the Centre are presented in this Annual Report.



## INTRODUCTION

Research on cashew was first initiated in the early 1950s. Indian Council of Agricultural Research (ICAR), sanctioned ad-hoc schemes for Research Centres located at Kottarakkara (Kerala), Ullal (Karnataka), Bapatla (Andhra Pradesh), Daregaon (Assam) and Vengurla (Maharashtra). In 1971, ICAR also sanctioned All India Coordinated Spices and Cashew Improvement Project (AICS and CIP) with its Head Quarters located at CPCRI, Kasaragod. The CPCRI Regional Station, Vittal (Karnataka) was given the mandate to carry out research work on cashew while four University Centres (Baptala, Vridhachalam, Anakkayam and Vengurla) were assigned the research component on cashew under AICS and CIP. During the V and VI plan 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 had resulted in the establishment of National Research Centre for Cashew at Puttur on 18<sup>th</sup> June 1986. Subsequent to the bifurcation of AICS and CIP, the headquarters of All India Coordinated Research Project on Cashew was shifted to NRC for Cashew, Puttur. At present, this Coordinated Research Project is operating in eight centres and a sub centre distributed in major cashew growing areas of the country.

### 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

- National Research Centre for Cashew 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. Experimental Station at Shantigodu, which also forms part of the research centre is 13 KM away from the main campus and has an area of 80 ha.
- The centre has got well-established library in the field of cashew research. The library is serving as an information centre on all aspects of cashew research and development in the country. The CD database viz., CABHORT, CABPEST, AGRICOLA and AGRIS, SOIL CD, CROP CD, PLANTGENE CD and TROPAG CD are also available in the library. The library also has library automation software and bar-coding facility. The library has 1093 books and 1500 back volumes of various journals. The library subscribes 33 National and 15 International journals. The library has J-gate on-line journal portal and Tech - Focuz digital library software.
- The centre has got local area network of computers with Internet connections. The centre has got its own website which is updated at monthly intervals.
- The headquarters of AICRP on Cashew is located at NRC Cashew, Puttur. It has eight 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.

### SIGNIFICANT ACHIEVEMENTS

- It has the largest germplasm collection of cashew in the country (National Cashew Field Gene Bank) with 509 accessions. A total of 433 cashew accessions have been assigned with National Collection numbers. The conservation block of gene bank has been established with 320 evaluated accessions by planting four plants of each accession.
- It has released two selections, 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 and cashew plants raised by micro grafting have been potted and field planted.
- Protocols have been standardized for characterization of released varieties and cashew germplasm accessions using RAPD/IISR markers and isozymes.
- The Centre has also demonstrated the advantage of growing intercrops like pineapple, turmeric, brinjal and chillies profitably in cashew gardens.
- Glyricidia grown as intercrop during initial years contributed 5.75 t/ha of dry matter, equal to 186 kg N, 40.8 kg P<sub>2</sub>O<sub>5</sub> and 67.8 kg K<sub>2</sub>O/ha.
- Individual tree terracing with crescent bunding is the best soil and water conservation measure in slopy lands.
- High density planting (625 plants density/ha) is better than normal spacing (8m x 8m) resulting in a 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.
- Soil and water conservation techniques like modified crescent bund or staggered trenches with coconut husk burial treatments have helped in conserving soil moisture, reducing the annual runoff / soil loss and increasing the nut yield.
- 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 reduces the level of CSRB incidence in a given location.
- Chlorpyrifos (0.2%) is effective for post-treatment prophylaxis measure against CSRB.
- Volatiles and extracts in hexane from both healthy bark and frass on testing by EAG elicit response from adult female beetles of CSRB.
- Laboratory rearing technique for tea mosquito bug (TMB) has been standardized. λ-cyhalothrin is effective in reducing the damage under field condition.
- Residues of insecticides used for the management of pests of cashew were not detected in the kernels of the raw nuts collected from the treated plots and the samples collected from the major cashew growing areas of the country.
- Sweetened and flavoured spread could be prepared from cashew kernel baby bits. Cashew kernel baby bits could be coated with different combination of flavour and colours. Cardamom flavoured and apple green / saffron coloured and sweetened cashew kernel baby bits are most preferred. Sweetened and flavoured cashew kernel baby bits have shelf life of 12 months at ambient temperature.
- Mineral composition of defatted cashew kernel

flour testa and cashew apple pomace of released varieties vary. Mineral composition of cashew apple pomace could be improved by blending with defatted flours of either cashew or almond.

- Cashew apple powder lipids are rich in unsaturated fatty acids and the major fatty acids are palmitoleic and oleic acids. Salt treatment of cashew apple resulted in the reduction of tannin 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 Centre has established very good linkage with farmers and officials of State Departments and Development Agencies.

### BUDGET (2007-'08)

(Rs. in lakhs)

Plan	Non-Plan	External	Total
90.74	168.60	8.81	268.15

### STAFF POSITION AS ON 31.3.2008

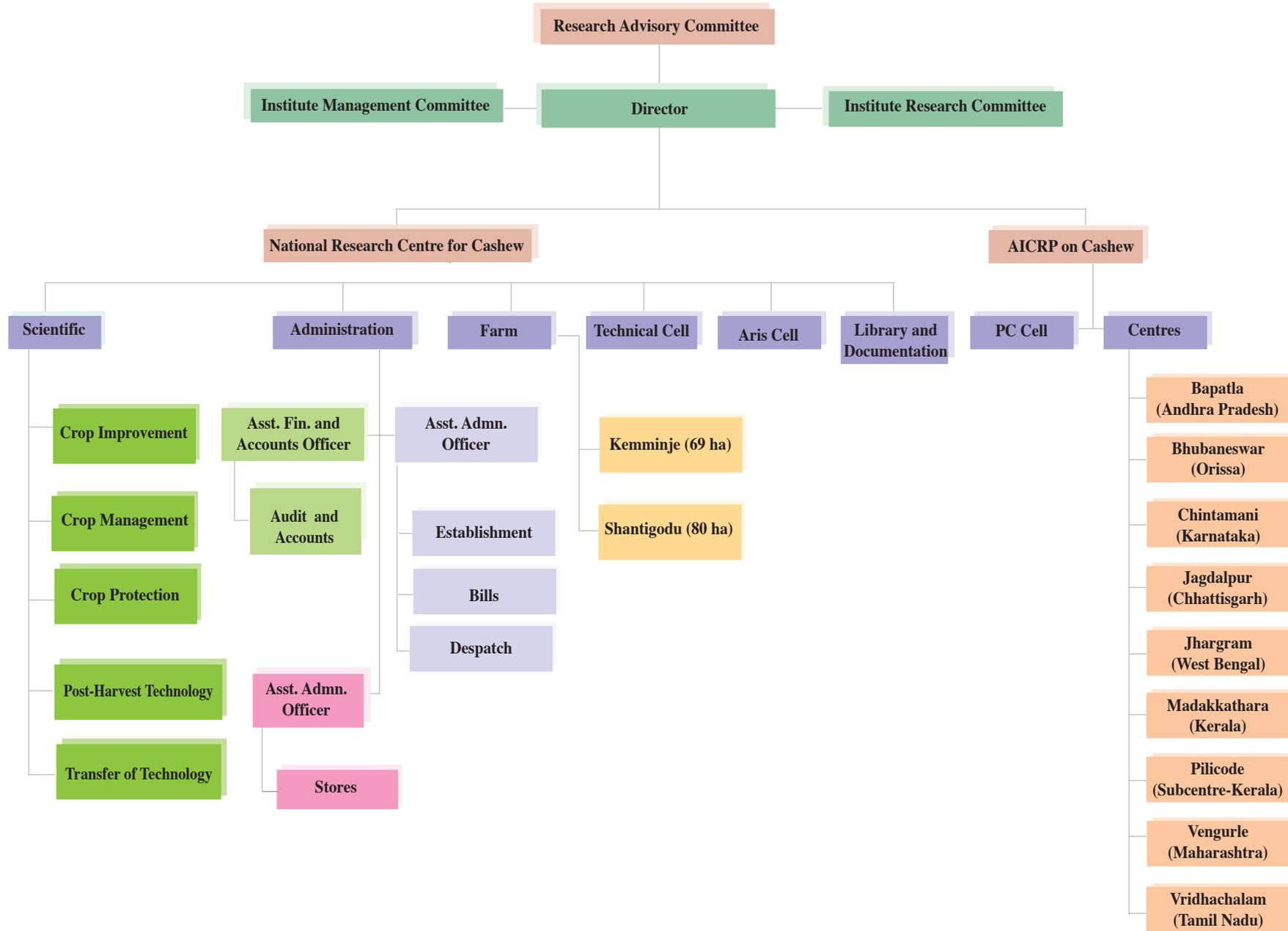
Category	NON PLAN			PLAN			TOTAL		
	Sanct- ioned	Filled	Vacant	Sanct- ioned	Filled	Vacant	No. of Posts	No. filled	Vacant
Director (RMP)	1	1	-	-	-	-	1	1	-
Scientific	18	11	7	-	-	-	18	11	7
Technical	19	18	1	4	-	4	23	18	5
Administrative	14	14	-	1	-	1	15	14	1
Supporting	41	38	3	-	-	-	41	38	3
Canteen	1	1	-	-	-	-	1	1	-
<b>Total</b>	<b>94</b>	<b>84</b>	<b>11</b>	<b>5</b>	<b>-</b>	<b>5</b>	<b>99</b>	<b>83</b>	<b>16</b>

### TOTAL MANPOWER

	Sanctioned	Filled	Vacant
Non Plan	94	83	11
Plan	5	-	5
<b>Total</b>	<b>99</b>	<b>83</b>	<b>16</b>



## ORGANISATIONAL SETUP OF NRC-CASHEW





# RESEARCH ACHIEVEMENTS

## 1. CROP IMPROVEMENT

### 1.1 Genetic resources of cashew

#### 1.1.1 Germplasm collection

Random germplasm survey was undertaken in North Eastern States particularly Arunachal Pradesh (Itanagar, Chessa and surrounding areas where stray cashew plants were seen), Manipur (Jiriboom region), Mizoram (Aizwal, Kolasib and Vairangte region) during the fruiting season of June 2007. From Itanagar, a high yielding plant with medium nut size and one plant at Chessa Forest Research Farm with late bearing and profuse bearing types were identified for collection. In Manipur, Jiriboom area was surveyed and one tree from State Horticultural Farm was identified for collection. In Mizoram State, cashew cultivation was taken up in 1970's in Vairangte area by Soil Conservation Department to overcome soil erosion in zoom lands. Recently, they were cut and a few trees are remaining. A tree with high yield of medium nut size was identified

for collection.

Comprehensive survey was undertaken in Andamans during the fruiting season of 2008 (March-April). In South Andamans mostly trees with small nut types were observed. Two medium nut types with high yield were identified for collection. In Tugapur (middle Andaman) a high yielding type with bold nut was identified for collection. Similarly, four bold nut types with high yield were identified for collection from Diglipur (Table 1.1). Besides this, a wild relative of cashew locally known as 'Jungly caju' has also been identified for collection in middle Andaman.

#### 1.1.2 Germplasm conservation

During the planting season three bold nut type collections made during previous season were planted in National Cashew Field Gene Bank (NCFGB) thus raising the holding in NCFGB to 509. The germplasm conservation block established with 320 accessions has

**Table 1.1 : Details of cashew trees identified for germplasm collection in Andamans**

Collection no.	Name of the village and specific nos.	Age of the tree (years)	Criteria for selection	Yield (kg/year)	Mean nut weight (g)	Apple type
Andaman-1	Chowlidhar-1	15	Profuse flowering	5-6	7	Red apple Medium size (60-90g)
Andaman-2	Kamrajnagar-1	15 - 20	Medium nut size and good yield	8-9	7	Red apple Medium size (50-90g)
Andaman-3	Mount Hariet (Panighat)	10 - 12	Medium nut size and high yield	10-15	7	Red apple Round small
Andaman-4	No.7 Tugapur-1	7 - 8	High yield	12-15	8	Red and Yellow
Andaman-5	No.7 Tugapur-2	8 - 10	High yield and bold nut	20	8.5	Yellow Round (50-60g)
Andaman-6	Diglipur-1	10	High yield and bold nut	8-10	10.8	Red Medium
Andaman-7	Diglipur-2	6	Bunch and bold nut	3-4	10.1	Red apple
Andaman-8	Diglipur-3	6	Bold nut and bunch bearing	3-4	11.0	Yellow apple
Andaman-9	Diglipur-4	8 - 9	Bold nut and high yield	10-15	10.5	Red and Big apple
Andaman-10	Lalaji-1	50	High yield	30-40	6	Yellow
Andaman-11	Havlock-1	10	High yield	10-15	7	Yellow

been maintained. The accessions characterised so far have been planted at 4mx4m spacing @ four plants per accession.

Planting material has been generated from the identified trees in Arunachal Pradesh, Manipur and Mizoram for planting and conservation in NCFGB.

### 1.1.3 Germplasm characterization

During the flushing, flowering and fruiting season observations on 43 germplasm accessions planted during 1997 were recorded after completion

of 6 annual harvests for evaluation and characterization. Majority (67%) of the accessions were upright growing and had open canopy type, 74% had obovate leaf shape more than 60% of them were early flowering types, 44% had yellow apple, 44% had higher nut weight (>7g.), more than 80% had big apple, more than 80% had intermediate shell thickness, 65% had intermediate shelling percentage, majority (74%) had medium kernel weight (1.2 – 2.5 g) and all had low cumulative yield (less than 9 kg/per tree) (Table 1.2).

**Table 1.2 : Details of germplasm accessions evaluated and characterized**

Data field	Descriptor	No. of accessions		Descriptor status
04	Tree habit	3	11	Upright and Compact
		5	29	Upright and Open
		7	3	Spreading
09	Leaf shape	1	-	Oblong
		2	11	Obovate (Club shaped)
		3	32	Oval
16	Branching pattern	1	23	Extensive
		2	20	Intensive
19	Colour of young leaves	1	2	Red
		2	34	Yellow red
		3	7	Green yellow
		4	-	Purple
28	Season of flowering	3	26	Early (Nov – Dec)
		5	12	Mid (Dec – Jan)
		7	5	Late (Jan – Feb)
31	Colour of mature apple	1	19	Yellow
		2	18	Red
		3	6	Yellow Red
		4	-	Red Purple
32	Shape of cashew apple	1	12	Cylindrical
		2	23	Conical Obovate
		3	8	Round
		4	-	Pyramidal
35	Nut weight	3	6	Low (< 5g)
		5	18	Intermediate (5 – 7 g)
		7	19	High (> 7g)
43	Weight of cashew apple	3	-	Low (< 27g)
		5	7	Medium (27 – 52 g)
		7	36	High (> 52 g)
50	Attachment of nut to apple	3	29	Loose
		5	10	Intermediate
		7	4	Tight
57	Shell thickness	3	7	Thin (< 2.5 mm)
		5	36	Intermediate (2.5 – 4.0 mm)
		7	-	Thick (> 4.0 mm)
60	Flowering duration	3	-	Short (< 60 days)
		5	18	Medium (60 – 90 days)
		7	25	Long (> 90 days)
62	Apple to nut ratio	3	-	Low (< 6.0)
		5	34	Medium (6.0 – 12.0)
		7	9	High (> 12.0)
63	Shelling percentage	3	6	Low (< 18.0%)
		5	28	Intermediate (18.0 – 28.0%)
		7	9	High (> 28.0%)
64	Kernel weight	3	8	Low (1.2 g)
		5	32	Intermediate (1.2 – 2.5 g)
		7	3	High (> 2.5 g)
65	Attachment of peel to kernel	3	39	Loose
		7	4	Tight
68	Cumulative yield	3	43	Low (< 9 Kg)
		5	-	Medium (9 – 18 Kg)
		7	-	High (> 18 Kg)

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

The hybrids, H-66, H-68 and H-43 of cross combinations NRCC Sel-2 x Bhuthnath-II yielded 5.40, 4.90, and 5.35 kg/tree in the 4<sup>th</sup> harvest with a cumulative yield of 19.86, 18.80, and 19.53 kg/tree in four harvests respectively. Hybrids, H-125 and H-126, of cross combinations, NRCC Sel-2 x Bhedasi yielded 5.55 and 5.00 kg/tree in their 4<sup>th</sup> harvest with a cumulative yield of 19.45 and 17.79 kg/tree in four harvests respectively.

A reported precocious dwarf KGN-1 from Madakkathara (Thrissur ) centre of AICRP-Cashew planted at 4mx4m in August 2002 and evaluated along with NRCC Sel-2 did not exhibit the characteristics of dwarf plant with respect to plant height, stem girth, mean canopy spread and internodal length (Table 1.3).

## 1.3 Molecular characterization of germplasm accessions

During the year, 118 accessions were characterized in two groups (75, 43 accessions) using both RAPD and ISSR markers. In the first group, 75 germplasm accessions were fingerprinted with 10 selected primers each of RAPD and ISSR markers. With 10 RAPD primers, 62 bands were generated with a polymorphism of 72.6% (45 bands). The Polymorphic Information Content (PIC) values varied from 0.184 to 0.359 and marker index (MI) values from 0.45 to 1.79. Dendrogram made based on similarity values revealed that NRC-244 and NRC-214 are as highly divergent. Similarly, with 10 ISSR primers, 69 bands with polymorphism in 59 bands (85.5%) were recorded and their PIC values varied from 0.146 to 0.391 and MI values from 0.584 to 2.346. Dendrogram made based on similarity values (ISSR) revealed high divergence in case of NRC-269 and NRC-214. Both RAPD and ISSR primers revealed that NRC-231 and NRC-232 are highly genetically similar. Markers of both RAPD

and ISSR were combined to get a total of 194 bands with polymorphism in 136 bands (70.1%). The dendrogram made with the similarity values of combined markers showed high divergence in case of NRC-244 and NRC-214 and highest similarity (94%) between NRC-231 and NRC-232.

In the second group, 43 accessions were similarly assessed with polymorphic markers generated using the above 10 primers each of RAPD and ISSR. Combined markers (156) were used for the analysis. Similarity coefficient of 0.39-0.77 indicated wide divergence among the accessions. Dendrogram made to group accessions separated the accessions broadly into two groups and one of the groups could be further divided in to several smaller groupings. It also revealed higher divergence in case of NRC 432, NRC 375 and NRC 158(Fig.1.1).

## 1.4 Molecular characterization of varieties

### 1.4.1 ISSR markers

Characterization of 40 varieties was undertaken with ISSR makers. With 10 selected primers of ISSR, a total of 88 bands were generated with a polymorphism of 87.5% (77 bands). The PIC varied from 0.166 to 0.355 and the marker index from 1.12 to 4.2. As in SSR markers, dendrogram made with ISSR revealed two major groupings of varieties and in that one group could be further segregated into several small clusters. By ISSR markers, VTH 174 (H 4-7), Dhana and V-6 were found highly divergent and Goa-1 and NRCC Sel-2 were highly genetically similar (94%).

### 1.4.2 SSR markers

Similarly, 40 cashew varieties were characterized using 21 pairs of SSR primers made from cashew gene sequence. 15 pairs of SSR primers were employed to generate polymorphism. 1-4 bands/primer were generated on 3.5% Hi-Res<sup>TM</sup> Agarose electrophoresis. Range of similarity index varied from 0.58 to 0.97. The cluster diagram distinguished broadly

**Table 1.3 : Performance of KGN-1 for plant growth characters in comparison with NRCC Sel-2 ( Check ) at five and half years of age**

Characters	KGN-1	NRCC Sel-2 ( Check )
Plant height ( m )	4.60	4.56
Stem girth ( cm )	43.27	49.70
Mean canopy spread ( m )	4.01	4.60
Internodal length ( cm )	2.45	2.27

two groups and one of the major groups could be further divided into smaller groups. Among the varieties VRI-3, Bhaskara and V-6 were found to be highly divergent and Ullal-4 and H 32-4 were genetically highly similar (97%).

### 1.4.3 Combined markers

The markers data of RAPD, ISSR and SSR were combined to estimate the similarity index (Jacquard's) and it varied from 0.70 to 0.84 indicating narrow diversity among the varieties. Highest similarity was observed between Bhaskara and VRI-3 and Ullal-4 and H 32-4. At 75% similarity, UPGMA diagram could classify the varieties broadly into two groups. One of the groups could be separated further into several smaller clusters. Among the accessions Kanaka, VRI-2 and V-6 were highly divergent and Bhaskara and VRI-3 were highly similar.

### 1.5 Identification of molecular markers linked to economic characters

Phenotypic evaluation of 251 F2 plants of

VRI-2 X VTH 711/4 cross were evaluated for morphological, physiological, flowering, fruiting and yield characters. Wide variation in plant height, canopy spread, leaf area, apple weight and yield was noticed. Plants were selected based on their high phenotypic value and low phenotypic values for bulk segregant analysis. DNA was also isolated from cashew leaves of parents (P1, P2), F1 and 143 selected F2 plants (based on low and high phenotypic values) following CTAB method.

Optimization of PCR conditions and other parameters for different marker systems (RAPD, ISSR and SSR) was carried out including for the bulks. DNA of parents and F1 hybrid were screened with 124 RAPD, 31 ISSR and 15 SSR primer pairs and observed polymorphism (parental) in 53 RAPD, 11 ISSR and 7 SSR primer pairs. Bulk segregant analysis was carried out by screening nine polymorphic primers of RAPD with P1, P2, F1 and two bulks each constituted (based on nut size) from F2 and germplasm, a putative marker for small nut size was identified in germplasm bulks.

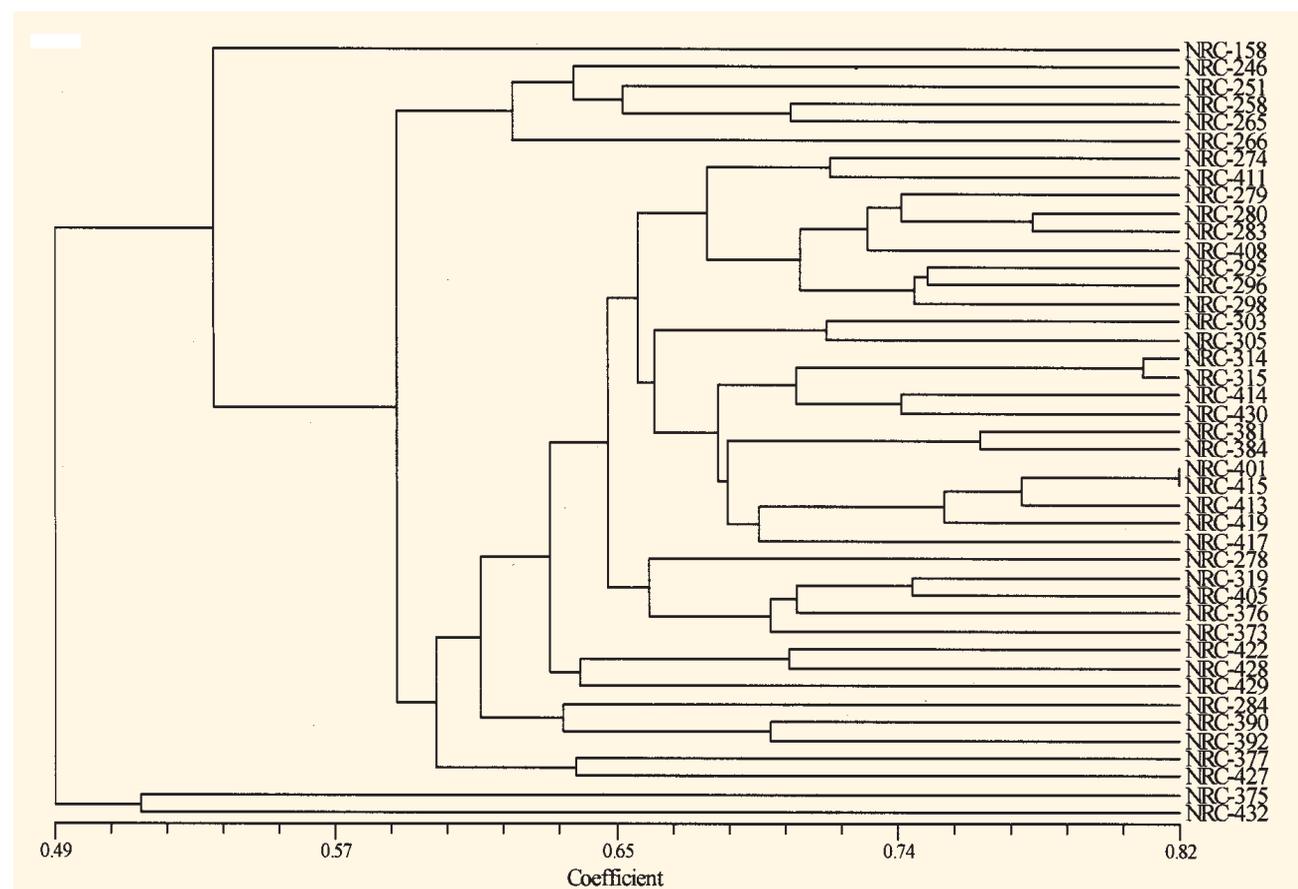


Fig. 1.1 : Cluster diagram of 43 germplasm accessions of cashew based on RAPD and ISSR markers

## 2. CROP MANAGEMENT

### 2.1 Fertilizer application and pruning in high-density plantation

This experiment was taken up to study the nutrient requirement /unit area at three different plant densities. The experiment was laid out in 2001 with three plant densities viz., 200 (S1), 416 (S2) and 500 (S3) plants /ha as main plot treatments and three fertilizer doses viz., 75 kg N, 25 kg each of P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O (M1), 150 kg N, 50 kg each of P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O (M2), 225 kg N, 75 kg each of P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O/ha (M3) as sub plot treatments.

#### 2.1.1 Ground coverage and light interception by tree canopy

In high tree density plots (416 and 500 trees/ha), the ground coverage and light interception by the canopy was 70-83 % and 49-67 % respectively compared to 48 to

50 % and 14-20 % in normal density planting system (200 trees/ha) seven years after planting (Table 2.1 and 2.2).

#### 2.1.2 Yield

The yield in the high tree density plots (416 and 500trees/ha) was significantly higher (1093 and 1078 kg/ha) than in normal tree density plot (511 kg/ha) six years after planting. Among the subplots (fertilizer doses) the yield decreased significantly as fertilizer level increased from M1 (961 kg/ha) to M3 (835 kg/ha). Interaction effect of tree density and fertilizer levels was not observed (Table 2.3). The cumulative yield for four harvests indicated that so far maintaining highest tree population of 500 /ha has given highest yield of 3616 kg/ha and maintaining tree population of 416 trees/ha gave next highest yield of 3205 kg/ha. In normal tree density the cumulative yield

**Table 2.1 : Ground coverage (sq.m.) by tree canopy seven years after planting (2007)**

Treatment	M1	M2	M3	Mean
S1-200 trees/ha	52.16	50.42	48.18	50.25
S2-416 trees/ha	70.30	73.75	72.80	72.28
S3-500 trees /ha	83.00	83.00	83.00	83.00
Mean	68.48	69.05	67.99	

**Table 2.2 : Per cent light interception by canopy in the allotted area (2007)**

Treatment	MI	M2	M3	Mean
S1-200 trees/ha	13.97	16.80	19.93	16.9
S2-416 trees/ha	49.00	57.00	56.30	54.1
S3-500 trees /ha	62.62	63.30	67.34	64.42
Mean	41.86	45.70	47.86	

**Table 2.3 : Yield 7 years after planting (kg/ha)**

Treatment	M1	M2	M3	Mean
S1-200 trees/ha	493.6	502.3	539.3	511.7
S2-416 trees/ha	1129.6	985.6	1163.3	1092.8
S3-500 trees /ha	1259.3	1173.5	801.3	1078.0
Mean	960.8	887.1	834.6	
Sem (spacing)				120.9
Sem ( manure)				75.7
CD(0.5)-spacing				295.5
CD (0.5)-manure				NS

recorded was 1622 kg/ha which is significantly lower than the other two treatments (416 and 500 trees/ha.) (Table 2.4).

## 2.2 Performance of high yielding varieties of cashew under different high density planting system

Field experiment was laid out in 2006 with fresh planting of grafts of nine varieties, each one in four different densities (spacings). The main objectives of the experiment are as follows:

To determine optimum plant density for achieving highest yield and profits for the first ten years.

To recommend suitable variety for achieving highest yield and profit for the first ten years under high density planting system.

### Treatments

#### Main plot

#### Density (No. /ha, Spacing m x m)

S1-200 (10mx5m), S2-236 (6.5m X 6.5m), S3-384 (6.5m X 4m), S4-500 (5 m X 4m)

### Sub plot (Varieties)

T1-VRI3, T2-NRCC Sel 2, T3-V7, T4-Ullal-1, T5-Dhana, T6- Madakkathara-2, T7-Ullal-3, T8-V4, T9-Bhaskara

Design: Split plot, Replication-3, Plot size-36 plants/main plot, 4 plants / sub plot, Border plants around treatment plants.

### 2.2.1 Initial observations on growth

Stem girth of varieties like NRCC Sel-2 (11.37cm), V-7 (12.50 cm), Ullal-1(11.67cm), Dhana (11.34 cm), Ullal-3 (12.33cm) and Bhaskara (14.29cm) was more compared to stem girth of other varieties. Least girth of the stem was observed in the case of VRI-3 (9.25 cm) and Madakkathara-2 (9.13cm) varieties (Table 2.5). The varieties like V-7 (191.67cm), Ullal-1 (189.58cm), Dhana (178.13cm) and Bhaskara (177.08 cm) were taller than other varieties. The height was least in the case of variety Madakkathara-2 (134.31cm) (Table 2.6). Canopy area was highest (3.35 sq.m.) in the case of Bhaskara variety compared to other

Table 2.4 : Cumulative yield (2004-07)

Treatment	MI	M2	M3	Mean
S1-200 trees/ha	1556.4	1591.2	1717.0	1621.5
S2-416 trees/ha	3103.0	2960.4	3552.7	3205.4
S3-500 trees /ha	3731.1	3911.2	3205.4	3615.9
Mean	2796.8	2820.9	2825.0	

Table 2.5 : Effect of plant density and varieties on the girth of stem at 0.75m above the ground two years after planting

Varieties	VRI-3	NRCC Sel-2	V-7	Ullal-1	Dhana	Madakka-thara-2	Ullal-3	V-4	Bhaskara	Mean
Treatments-plants/ha										
S1-200	9.50	11.50	12.17	11.67	14.17	7.17	11.33	8.67	11.33	10.83
S2-236	8.00	8.67	13.50	10.67	9.83	8.17	10.67	11.00	12.17	10.30
S3-384	11.83	13.00	12.17	13.17	12.17	11.67	13.33	11.50	15.83	12.74
S4-500	7.67	12.33	12.17	11.17	9.17	9.50	14.00	9.00	9.50	10.50
Mean	9.25	11.37	12.50	11.67	11.34	9.13	12.33	10.04	14.29	
CD(MP)										NS
CD(SP)										2.38

Table 2.6 : Effect of plant density and varieties on the height of plant two years after planting (cm)

Varieties	VRI-3	NRCC Sel-2	V-7	Ullal-1	Dhana	Madakka-thara-2	Ullal-3	V-4	Bhaskara	Mean
Treatments-plants/ha										
S1-200	158.33	179.17	200.00	170.83	208.33	129.17	175.00	158.33	166.67	171.76
S2-312	145.83	137.50	195.83	191.67	166.67	104.17	162.50	180.83	145.83	158.98
S3-384	179.17	195.83	216.67	212.50	195.83	158.33	187.50	166.67	208.33	191.20
S4-500	145.83	187.50	154.17	183.33	141.67	145.83	115.00	125.00	187.50	153.98
Mean	157.29	175.00	191.67	189.58	178.13	134.37	160.00	157.70	177.08	
CD(MP)										NS
CD(SP)										31.26

varieties. Least canopy area was observed in the case of VRI-3 variety (Table 2.7). Growth in terms of girth, height and canopy area were highest in the case of plants grown under moderate high density planting system (384 plants/ha) compared to other planting density system.

### 2.3 Rejuvenation of trees of high density cashew orchard through canopy management

Field experiment was laid out in 2006 on 12 years old VRI-1 and seven years old Bhaskara variety. The main objectives of the experiment are as follows.

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

Working out cost of maintaining limb pruned and top worked trees and profits realised subsequently for recommendation to the farmers.

#### Treatments

1. Pruning at 1m height of the branches emerging after limb pruning (decrowning) or top working once in a year.

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

Three sets of experiment will be laid out in (1) limb pruned trees of 12 years old VRI-1 variety, (2) limb pruned trees of VRI-1 and subsequently top worked with scions of Bhaskara variety and (3) limb pruned trees of Bhaskara variety.

Design: RBD, Treatments-5, Replication-4, Plot size- 2 plants per plot.

Pruning of the detopped and top worked trees at 1m height was done and treatment against stem borer attack was done. Imposing treatment of application of paclobutrazol was done during October 2007. The

Table 2.7 : Effect of plant density and varieties on the canopy area two years after planting (sq.m.)

Varieties Treatments- plants/ha	VRI-3	NRCC Sel-2	V-7	Ullal-1	Dhana	Madakka- thara-2	Ullal-3	V-4	Bhaskara	Mean
S1-200	2.18	3.00	2.46	2.18	2.18	1.39	2.64	2.32	3.45	2.42
S2-312	2.20	1.31	3.07	2.74	2.24	1.13	3.13	2.36	2.15	2.26
S3-384	2.13	2.83	3.15	3.27	2.41	2.79	3.97	2.51	4.40	3.05
S4-500	1.29	2.74	2.49	2.43	1.85	1.75	2.02	1.73	3.41	2.19
Mean	1.95	2.47	2.79	2.66	2.17	1.77	2.94	2.23	3.35	
CD(MP)										NS
CD(SP)										0.97



Trees treated with paclobutrazol in the front and at the back side normal tree without paclobutrazol treatment



Fruiting cashew tree treated with paclobutrazol and untreated tree (behind)

tree height, canopy height and spread of trees treated with paclobutrazol were 50 % less than trees receiving control treatment. Only in case of trees receiving paclobutrazol flowering was observed (3 panicles/tree) whereas in case of control plot with no further pruning after limb pruning flowering was not observed (Table 2.8).

#### 2.4 Green manuring in cashew for increasing productivity of cashew

Cashew with four green manuring crops was planted with the following five treatments namely: (i) cashew with sunhemp, (ii) cashew with sesbania, (iii) cashew with glyricidia (iv) cashew with cover crop (*Calapagonia muconoides*) and (v) cashew alone. This experiment was started in 2001 and is continued upto 2008. Both main and green manure crops were raised in 2001 and green manure crops like sunhemp and sesbania were sown each year. Glyricidia, being perennial, seeds were sown in 2001 and three cuttings per year were given. Four green manure crops were grown in between two rows of cashew planted at 4m x 4m distance. The control plot was maintained by growing cashew alone (without any green manure crop). These treatments were replicated four times and laid out by adopting RBD. Green biomass production was estimated and collected green biomass was applied back to the plot to improve the soil fertility. Soil samples were analysed for moisture and nutrient contents. Cashew leaf samples were also analyzed for nutrient contents.

##### 2.4.1 Soil moisture content

During January 2008, the soil moisture content was highest in cashew garden with glyricidia as green

manuring crop (17 % to 18.6 % dry basis) compared to sunhemp (17.8 to 18.3 % dry basis), sesbania (15.5 to 18.2 % dry basis), cover crop (14.7 to 17.4 % dry basis) and control (15.5% to 17 % dry basis). During February also, the highest soil moisture content of 13.4% to 13.9% dry basis was observed in glyricidia plot compared to sunhemp (11.3 to 13.3%), sesbania (10.5 to 12% db), cover crop (10.3 to 11.8 % dry basis) and control plot (10.1 to 10.9% db). The mean soil moisture in glyricidia plot was 1.5% dry basis and 3.3% dry basis more than the control plot in January and February.

##### 2.4.2 Nutrient content of the soil and leaf

Most of the major and minor nutrients present in the soil were highest in glyricidia plot compared to sunhemp, sesbania and cover crop (*Calapagonium muconoides*) and cashew alone (control). The organic carbon content (OC) was highest (0.98%) in plot with glyricidia, 0.66% in plot with sunhemp and lowest (0.5%) in control with cashew alone. Similarly, the content of P<sub>2</sub>O<sub>5</sub> was highest (23.6 kg/ha) in plot with glyricidia and 9.1 kg/ha in control. The K<sub>2</sub>O content was highest in sesbania plot (162.3 kg/ha), then in sunhemp plot (141.1 kg/ha), glyricidia plot (126.2 kg/ha) and lowest in control (105.4 kg/ha). Highest Mg (glyricidia - 30.3 kg/ha and control -14.67 kg/ha), Cu (glyricidia- 1.43 ppm and control -0.78 ppm), Fe (glyricidia - 82 ppm and control -51 ppm), and Mn contents (glyricidia- 12.5 ppm and control - 5.7 ppm) was also observed in plot with glyricidia as green manuring crop compared to control and all other green manuring crops. The Zn content was highest in plot with sunhemp (36.9 ppm) and sesbania (34.8 ppm) compared to plot with glyricidia (27.87 ppm) as green

**Table 2. 8 : Effect of different treatments of canopy management on growth**

Treatment	VRI-1 (15 years)		Top worked on VRI-1 with Bhaskara		Bhaskara (6 years)	
	Height above portion of LP(m)	No.of leaves/branch	Height above portion of LP(m)	No.of leaves/branch	Height above portion of LP(m)	No.of leaves/branch
1	1.75	41	2.25	38	1.75	34
2	1.2	34	1.35	25	0.9	25
3	1.5	35	0.75	35	0.75	24
4	1.25	28	0.60	28	0.58	17
5	2.35	40	2.75	47	2.35	38

LP=Limb Pruning

manuring crop and control (20.22 ppm) (Tables 2.9 and 2.10).

Beneficial micro organisms in terms of microbial biomass produced is also high in glyricidia plot (229 µg c/g soil) next to sunhemp plot (261 µg c/g soil) (Table 2.9). The green manure crop glyricidia contributed 186 kg N, 23.6 kg P<sub>2</sub>O<sub>5</sub> and 126.2 kg K<sub>2</sub>O/ha and sesbania contributed 141 kg N, 17.9 kg P<sub>2</sub>O<sub>5</sub> and 162.3 kg K<sub>2</sub>O per ha (Table 2.9). Nutrient content

in leaf of cashew was highest in plot with glyricidia and cover crops (N - 1.88 and 1.97%, P - 0.28 and 0.40 %, K - 0.51 and 0.54 %) compared to other plots (Table 2.11).

### 2.4.3 Yield of cashew

The yield of cashew was highest in plots where sesbania and glyricidia were grown as green manuring crop (Table 2.12). Yield increased significantly in plot

**Table 2.9 : Effect of green manure crops on major nutrient contents of soil and microbial biomass in cashew plantation**

Green manure crop	OC (%)	N (kg/ha)	P <sub>2</sub> O <sub>5</sub> (kg/ha)	K <sub>2</sub> O (kg/ha)	Microbial biomass-µg c/g soil
Sunhemp	0.66	124	11.5	141.1	261
Sesbania	0.62	141	17.9	162.3	168
Glyricidia	0.98	186	23.6	126.2	229
Cover crop	0.59	87	20.9	97.0	149
No GM	0.50	76	9.1	105.4	160
CD (p=0.05)	0.19	7.49	1.56	1.77	

**Table 2.10 : Effect of green manure crops on soil minor and micronutrient contents of in cashew plantation**

Green manure Crop	Mg (kg/ha)	Fe (ppm)	Cu (ppm)	Mn (ppm)	Zn (ppm)
Sunhemp	16.4	65.7	1.1	6.4	36.9
Sesbania	16.4	62.4	0.9	7.0	34.9
Glyricidia	30.3	82.0	1.4	12.5	22.9
Cover crop	15.6	54.0	0.9	6.1	23.9
No GM	14.6	50.9	0.8	5.7	20.2
CD (p=0.05)	1.98	6.4	0.2	1.2	2.5

**Table 2.11 : Effect of growing green manure crops on leaf nutrient content (%)**

Treatment	N	P	K	Ca	Mg
Sunhemp	1.61	0.25	0.48	0.40	0.20
Sesbania	1.79	0.35	0.47	0.43	0.20
Glyricidia	1.88	0.28	0.51	0.46	0.20
Cover crop	1.97	0.40	0.54	0.58	0.20
CD (p=0.05)	0.34	0.07	0.11	0.08	0.06

**Table 2.12 : Effect green manure crops on cashew yield (kg/ha)**

Treatment	2007	Cumulative yield (4 years)
Cashew+Sunhemp	2102	4049
Cashew +Sesbania	1987	4562
Cashew +Glyricidia	2123	4558
Cashew +Cover crop	1678	3706
Cashew alone	1290	3039
Mean	1836	3983
SED	47	
CD (p =0.05)		102

with glyricidia as green manuring crop (2123 kg/ha in 2007) compared to sesbania (1987 kg/ha in 2007), other green manuring crops and control (1290 kg/ha in 2007). Even though, the cashew yield was equally good in sesbania plot in the long run, glyricidia as green manure crop for cashew is more beneficial than sesbania.

#### 2.4.4 Economics

The cost of cultivation was highest for sesbania (Rs.41617/ha) and sunhemp (Rs.40988/ha) as green manuring crop compared to cover crop (Rs.38613/ha), glyricidia (Rs.38113/ha) and control (Rs.32613/ha) (Table 2.13). Maximum profit of Rs.1, 21,434/ha was obtained from plot with glyricidia as green manuring crop in cashew garden compared to sesbania (profit of Rs. 1,18,060/ha), sunhemp (profit of Rs.1,00,699/ha), cover crop (profit of Rs.81,313/ha) and control with a profit of Rs.83,570/ha (Table 2.14).

#### 2.5 Efficacy of soil and water conservation techniques coupled with organic and inorganic manuring in cashew garden grown in slopy 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 slopy.**

In order to evaluate various soil and water conservation measures in relation to soil moisture, yield and economics, this experiment was laid out with five treatments namely, modified crescent bund (at 2 m radius having a crescent shaped bund of 6 m length, 1m width and 0.5 m height), 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), reverse terraces (2 m length, 2 m width and 0.7 m depth of cut), catch pits (3 m length, 0.5 m width and 0.5 m depth) and control plot without any soil and water conservation measure. It was laid out in RBD with four replications having 25 grafts of Madakkathara-2 variety planted along the contour in the year 2003. Two treatments of mulching for cashew plants using locally available plant materials and fodder *stylosanthes* was imposed for five plants each in the soil and water conservation experiment. The soil moisture content, cashew nut yield and growth data were recorded during 2007-08.

##### 2.5.1 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 during April to May 2007 and December 2007 to March 2008 and the soil moisture contents

**Table 2.13 : Cost of cultivation for each treatment for four years ((Rs./ha)**

Cultural operation	Cashew + Sunhemp	Cashew + Sesbania	Cashew + Glyricidia	Cashew + Covercrop	Cashew alone
Base clearing	13575	13575	13575	13575	13575
Weeding in interspaces	9350	9350	9350	9350	9350
Sowing seeds of green manure crops	9000	9000	5500	6000	-
Plant protection	2500	3125	3125	3125	3125
Picking of nuts	6563	6563	6563	6563	6563
Total	40988	41617	38113	38613	32613

**Table 2.14 : Economics of growing green manure crops in cashew garden**

Treatment	Cost of cultivation (Rs/ha)	Income (Rs/ha)	Profit (Rs/ha)	Yield (kg/ha)
Cashew+Sunhemp	40988	1,41,687	1,00,699	4048
Cashew +Sesbania	41617	1,59,677	1,18,060	4562
Cashew +Glyricidia	38113	1,59,546	1,21,434	4558
Cashew +Cover crop	38613	1,19,926	81,313	3426
Cashew alone	32613	1,16,183	83,570	3320
Mean	38389	139404	101015	3983
CD (5%)		28,200	27,900	797

(SMC) under different treatments were determined by gravimetric method. The available soil moisture ranged from 12 to 22% dry basis. During April 2007, the mean SMC was highest in the modified crescent bund, staggered trenches with coconut husk burial and reverse terrace treatments (14.9, 14.3 and 13.2 % dry basis) compared to 11.3 % dry basis (below the available soil moisture range) in control. In May, the soil samples were collected after a rainfall of 75 mm. The increased SMC at the lower layers of soil in the best treatment plots were 22.4 to 24.1 % dry basis compared to 19.1 to 19.8 % dry basis in control.

During December 2007, maximum soil moisture content of 19.4 to 21.8% dry basis in the lower layers of soil (31-90 cm) was observed in the case of modified crescent bund treatment, coconut husk burial treatment and mulching treatments compared to control (15.2 to 17.9 % dry basis). In January, the soil moisture content in the upper layer of soil (0-30 cm) was same in all the treatments (15.6 to 16.0 % dry basis) except catchpit treatment and control (9 to 12.4 % db). In the lower layers (31-90 cm) of soil, the SMC was highest in

coconut husk burial (17.9 to 19.6% db), modified crescent bund (17.5 to 19.4 % db), reverse terrace (17.2 to 19.2% db) and mulching treatments (16.7 to 18.3 %db) compared to control (13.9 to 15.6%db). During the month of February also, the mean SMC content was highest in the aforesaid best treatments compared to control (Table 2.15). During March, the soil samples in all the plots become saturated after the heavy rainfall (~100mm).

### 2.5.2. Growth and Nut Yield

Maximum stem girth of 54.75 cm, plant height of 4.6 m and canopy spread of 5.75 m was observed in the case of plants in modified crescent bund treatment compared to control (stem girth of 43.75 cm, plant height of 4.25 m and canopy spread of 4.3 m) and all other treatments (Table 2.16). Increased yield in the second harvest was also observed in the case of staggered trenches with coconut husk burial (702 kg/ha), modified crescent bund (671kg/ha) and reverse terrace treatments (654 kg/ha) compared to catch pit treatment (561 kg/ha) and control (451 kg/ha) plot without any soil and water conservation structures.

**Table 2.15 : Mean soil moisture (% dry basis) availability under different treatments (February 2008)**

Treatment	Depth (cm)			Mean
	0-30	31-60	61-90	
Modified crescent bund	13.7	16.2	17.4	15.8
Staggered trenches with coconut husk burial between 2 rows of cashew	14.8	16.5	18.0	16.4
Reverse terraces	13.3	16.1	17.3	15.6
Catch pits	09.1	13.5	13.8	12.1
Mulching with Stylosanthus	11.3	15.0	15.4	13.9
Local mulch application	11.4	14.8	15.3	13.8
Control plot without any soil conservation technique	8.6	12.9	13.6	11.7
Mean	11.7	15.0	15.8	
CD (5%) Treatment				1.72
CD (5%) Depth				0.90
CD (5%) TXD				1.02

**Table 2.16 : Growth Observations (2003 and 2008)**

Treatment	Tree height (m)		Canopy spread (m)		Stem girth (cm)	
	Initial	2008	Initial	2008	Initial	2008
Modified crescent bund	0.55	4.60	0.22	5.75	2.78	54.75
Staggered trenches with coconut husk burial between 2 rows of cashew	0.52	4.25	0.24	4.80	2.69	49.75
Reverse terraces	0.50	4.38	0.24	4.50	2.66	47.50
Catch pits	0.29	4.06	0.14	4.40	2.22	44.75
Control plot without any soil and water conservation measure	0.58	4.25	0.23	4.30	2.88	43.75

## 2.6 Root stock studies in cashew

Out of 12 different stionic combinations, only 9 combinations could be attempted due to lack of availability of dwarf seedlings on account of segregation and reduced germination. Among the attempted stionic combinations, the graft success ranged from 6 to 90 per cent (Table 2.17).

## 2.7 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

The most important factors responsible for the lower productivity of cashew in India are the non-use of grafts of improved varieties, lack of proper water, nutrient and pest management and non-adoption of regular spacing. Hence, there is a possibility of increased production by planting cashew grafts in barren areas and non-traditional areas, by substituting grafts of improved varieties with seedlings and also by proper water and nutrient management. These possibilities can be explored with the aid of GIS and Remote sensing techniques. Therefore, a methodology will be standardized to find the area under cashew,

barren areas and other non-traditional areas for expanding cashew cultivation. This study is proposed with the following objectives:

- To determine area under cashew and barren area for expanding cashew cultivation.
- To develop a spatial database to aid the decision making process for the optimal water and nutrient management.

For the preparation of spatial database, soil samples at two different depths (0-30 and 31-60 cm) from 10 different plots at Shanthigodu were analyzed for major and minor nutrients. The organic carbon content ranged from 0.42 to 0.93%,  $P_2O_5$  - 0 to 33 kg/ha,  $K_2O$  - 4.5 to 36.0 kg/ha, Ca - 20 to 97 kg/ha, Mg - 2.0 to 13.4 kg/ha, Fe- 8 to 144 ppm, Zn-0.5 to 51 ppm and Cu- 0.4 to 3.2 ppm. The soil moisture content at three different depths (0-30, 31-60 and 61-90 cm) were determined. During January and February 2008, the soil moisture content in the irrigated plots ranged from 19.8 to 22.7% db. In the unirrigated plots, majority of the plots had SMC in the upper layer (0-30 cm), ranged from 9 to 13.3% db and lower layers (31-90 cm) ranged from 10 to 15% db. With this data, the spatial data base has been prepared.

**Table 2.17 : Grafting success in different stionic combinations(%)**

Stionic combination (scion on root stock )	Success
VRI-3 / V-4	80
Ullal-3 / V-4	90
V-4 / V-4	50
Sel-2 / V-4	60
VRI-3 / Taliparamba	13
Ullal-3 / Taliparamba	20
Sel-2 / Taliparamba	06

## 3. CROP PROTECTION

### 3.1 Cashew stem and root borers

#### 3.1.1 Standardization of semi-synthetic diet (SSD)

The semi synthetic diet (SSD) comprising of saw dust, ground host bark, bengal gram flour, sucrose, agar-agar, vitamin supplements, yeast and an antifungal antibiotic; Griseofulvin in a specific proportion was prepared. The diet was earlier provided as SSD chunks placed in the rearing bottles. The grubs could feed normally on the diet, however, the feed utilization was minimal (20 - 35%), as the grubs could not tunnel inside the chunks for feeding. Development of saprophytic fungi and infestation by *Drosophila* were the main constraints in this method. In order to overcome these problems, the SSD in the molten state was directly poured into the rearing bottles and allowed to cool for 6 h. The mouths of such rearing bottles were covered using a clean paper sheet for further rearing of the CSR grubs. The infestation of *Drosophila* could be totally avoided by this method. The grubs could feed 60 to 80% of the SSD and the growth was comparatively better than those fed with SSD chunks. The frequency of diet change was reduced from once in 10 days to once in 30 days and no external addition / spraying of water was required. The molten SSD had a shelf life of more than 21 days.

#### 3.1.2 Survey for incidence of storage pests on stored cashewnuts and kernels

Cashew processing industries situated in Vetapalem and Chirala (Andhra Pradesh) were visited for collecting information on incidence of different storage pests. It was noticed that majority of the processors adopted contractual pest management in their premises during off-season. The cashew processing units situated in Palasa in Andhra Pradesh and in Dhenkanal, Rambha and Begunia in Orissa and Kollam in Kerala were surveyed. The survey indicated that the cashew nuts were stored in

godowns and the stock was well dried for 3-4 days and the duration of stock held was approximately 8 to 10 months. None of the factories reported mixing of different cashew lots as they needed information about the kernel recovery from each stock. All the factories had the storehouse exclusively for storing cashewnuts and no cross infestation from other stored material occurred.

The storage insect pests noticed predominantly were *Tribolium castaneum*, *Ephestia cautella*, *Oryzaephilus surinamensis* and *Rhyzopertha dominica*. Occurrence of *Tribolium castaneum* was the most commonly noticed in large numbers on rejects and testa stored in the ware houses. In few factories, *Rhyzopertha dominica* and *Oryzaephilus surinamensis* were also noticed. The infestation by *Ephestia cautella* was reportedly higher during the monsoon months (July to October) at both Orissa and Palasa (A.P.) and the stocks which were held for more than a month had some level of infestation by this pest. Hence, prior to dispatching the kernels to the packers / wholesalers, they were again reheated in Borma dryer.

It was reported in Orissa and Palasa (A.P.), that *E. cautella*, entered the space in between the two cotyledons and was not discernable externally, and also the butts (cross-cut whole kernels) were more susceptible to this pest than the higher grade kernels. Further, most of the processors mentioned that the incidence of *Tribolium castaneum* had increased due to the change in bulk transport of kernels wherein, the processed kernels are being transported in plastic crates whereas, kernels used to be transported earlier in sealed tins. This leads to accumulation of kernel dust on the external corrugations / ribs of the crates, wherein *Tribolium*, *Rhyzopertha* and *Oryzaephilus* multiply and re-infest the kernels duration further storage (Fig. 3.1).

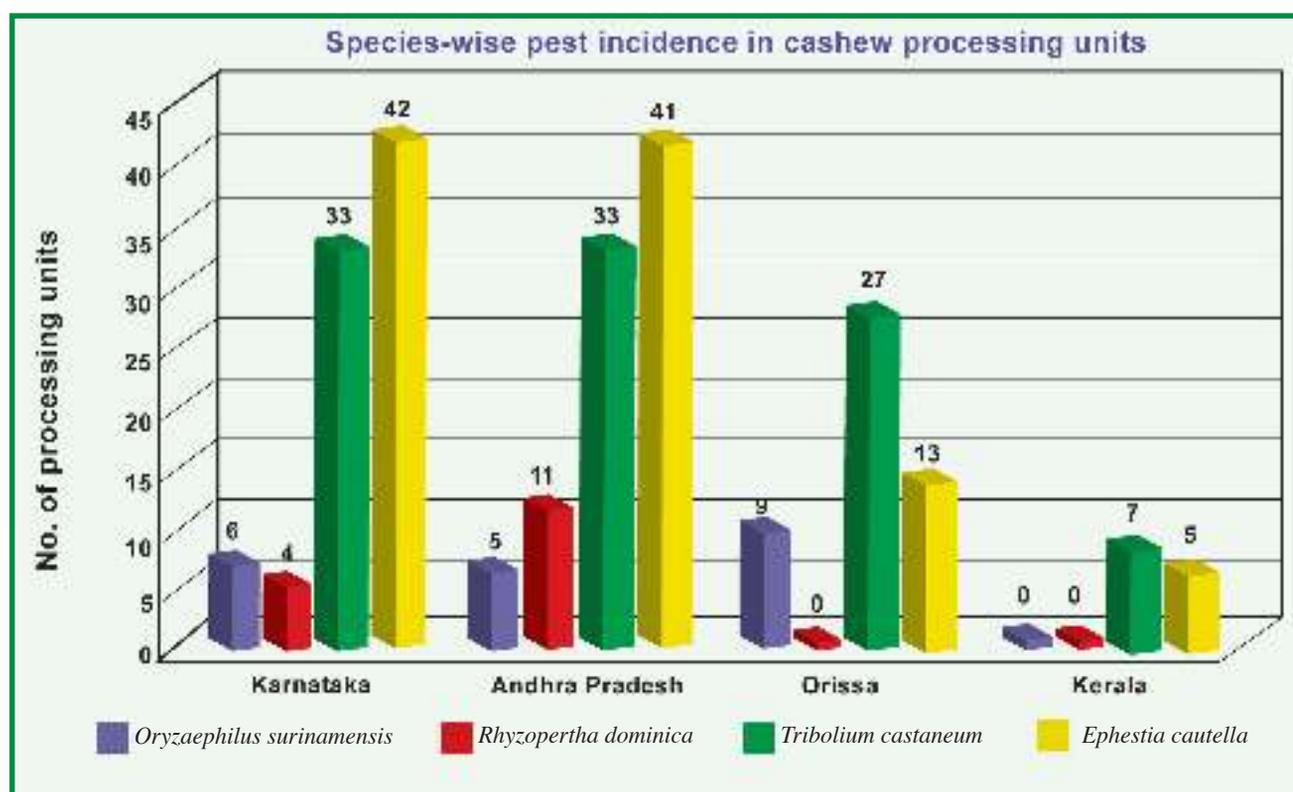


Fig. 3.1 Species-wise pest incidence in cashew processing units

### 3.2 Role of pollinators in improving productivity of cashew

#### 3.2.1 Honey bee colony establishment at Shanthigodu

The colonies of *Apis cerana* (honey bee) and *Trigona irridipennis* (Sting less bee) were established in the cashew garden at NRCC Experimental Station, Shanthigodu. But stray visit of honey bees on cashew flowers was observed. It was repeatedly found that pollen collectors returned to bee hive loaded with creamy/yellow coloured pollen which was not actually from cashew flowers. Similar observation was also noticed in the cashew gardens of Regional Research Station, Vridhachalam (Tamil Nadu). When stingless bee was confined within a cashew tree covered/caged with nylon mosquito net, all worker bees had distress flight and also escaped through mesh of the net and again had distress flight outside the nylon mesh cage for re-entry to its hive and ultimately workers could not return to the hive. As the result within one week's time, marked degeneration of colony was observed. Hence, the study was discontinued and subsequently, the colony was shifted to open shaded condition for further revival of colony.

#### 3.2.2 Visitation rate

The visitation rate of honey bees on cashew was observed on NRCC Selection-2, VRI-1, and V-4 cashew varieties. In all the varieties, the honey bees visited both male and bisexual flowers and collected nectar only. It ranged from  $1.89 \pm 0.81$ (S.D.) to  $3.55 \pm 1.46$  sec / flower. The non-*Apis* species (halictids and anthophorids) spent maximum time of 13 sec / flower in collection of nectar and pollen.

#### 3.2.3 Estimation of pollen load on stigma

During the forenoon hours (11AM to 12 Noon), the new bisexual flowers (before dehiscion of anther lobes) of NRCC selection-2 and VRI-1 visited by honey bees were collected individually and examined under the microscope to estimate the pollen load. It was found that 3.6 to 7.1 per cent of stigma only had pollen deposit. Further, gravitation fall of pollen grains from long stamen of male and bisexual flowers were estimated through stereoscopic microscope. For which, the newly opened flowers before dehiscion of anther lobes were collected kept in erect position in a flower rack designed for this purpose. On next day (within 24h of dehiscion of anther lobes), gravitation fall of pollen grains was observed only from bisexual flowers and it ranged from

3.3 per cent to 26.9 per cent of long stamens among seven accessions (V-1, V-2, Ullal-3, NRCC Sel.2, Bhaskara, Dhana and VRI-3) (Table 3.1). Among male flowers, no such gravitational of pollen grains observed. This indicated that geitonogamy pollination may also be possible by gravitational fall of pollen grains in accessions with higher percentage of bisexual flowers having dehiscent pollen lobes. This can be enhanced with least activities like wind breeze and insect flight activities.

**Table 3.1: Gravitational fall of pollen grains among cashew varieties.**

Variety	Flowers having fall of pollen grains from long stamen in bisexual flowers (%)
NRCC Selection-2	18.5
Ullal-3	26.9
Bhaskara	9.4
V-4	9.7
V-1	3.9
Dhana	10.8
VRI-3	3.3

### 3.2.4 Estimation of fruit set

For this purpose, the bisexual flowers were manually pollinated every day in "Bhaskara" cashew variety and such flowers were tagged with the help of sewing thread. The final fruit set was assessed between 35 and 40 days of pollination and by the time the nuts were in fully matured green nut stage. During the month of December 2006, a total of 464 flowers were manually pollinated within a period of 14 days. The final fruit set observed was 24.6 per cent whereas, under natural condition, the final fruit set was 10.1 per cent. When the correlation was worked out between number of flowers pollinated/day within a period of 14 days and number of final fruit set observed among those manually pollinated flowers/day, it was highly significant with positive correlation ( $r = 0.77^{**}$ ). The study has indicated the possibility of increasing the productivity of cashew through enhanced level of pollination.

### 3.2.5 Management of pollinators through faunal biodiversity

In order to enhance the population of pollinators (faunal biodiversity), at Shanthigodu Experimental

Station, the culms of *Saccharum spontaneum* were tied horizontally for natural nesting by pollinators of cashew (non-*Apis* spp.) on trunks of 36 trees of four cashew accessions. Similarly, tapioca stems, culms of *S. spontaneum* and plastic straw were also tied horizontally on trunks of VRI-2 & VRI-3 cashew varieties at Vridhachalam, Tamil Nadu. But the nesting of pollinators did not occur.

The faunal biodiversity of cashew pollinators existing on various weed species of cashew orchard during flowering season of cashew was observed at both coastal Tamil Nadu and Karnataka sites. In coastal Tamil Nadu (Vridhachalam), *Homalictus* sp., *Braunsapis* sp. and *Pseudapis oxybeloides* were observed on *Cleome viscosa*, *Leucas aspera*, *Celosia* sp. and mustard crop and they never visited cashew except one cashew accession (Goa 11/6) in germplasm. In one site, visit of *Apis florea* was seen both on *Celosia* weed as well as on VRI-3 cashew variety. But in another site where both cashew (germplasm) as well as *Celosia* weed existed, the above mentioned species of pollinators were not seen simultaneously both on the cashew and the weed. Such inconsistency was observed in Tamil Nadu sites. Whereas, in coastal Karnataka, *P. oxybeloides*, *Lasioglossum* sp., and *Braunsapis* sp. visited both cashew as well as three non invasive annual weeds (*Blumea lacera*, *B. oxydonta* (Asteraceae) and *Rungia parviflora* (Acanthaceae) with specific exclusive separate constancy pattern on cashew and weeds.

In order to find out any faunal diversity entering through mosquito net cage, a cashew tree of "Bhaskara" variety (Goa 11/6) was caged completely. By this, visit of honey bees, stingless bees and *P. oxybeloides* were excluded and possibility of entering of small bees such as *Lasioglossum* sp., and *Braunsapis* sp. had existed. When all adjoining trees were in full bloom, full level of fruit set has been completed within 30-45 days of initiation of flowering due to visit of above listed pollinators on all the open uncovered trees of "Bhaskara" cashew variety. But in the caged tree, no fruit set was observed during corresponding period despite regular visit by ants (*Camponotus* sp.). Subsequently, fruit set was observed in the caged tree beyond 45-60 days of initiation of flowering. The entry of *Lasioglossum* sp. through the mesh of the net was confirmed and visit of the same bee to most of the panicles of the caged tree was also observed. This resulted in the final fruit

set in 71.2 per cent panicles with a mean of 1.2 nuts/panicle, whereas, in the marked uncovered tree, final fruit set was observed in 81.3 per cent panicles with a mean of 2.1 nuts/panicle. Thus, the present study has indicated that cashew fruit set is possible even without the visit of above bees (honey bees, sting less bees and *P.oxybeloides*) and ants (*Camponotus* sp.) had no role in pollination.

### 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  $\lambda$ -cyhalothrin (0.003%) were got analyzed. The samples collected on 0, 1, 3, 7 and 15 days after treatment were analyzed for the residues of the insecticides. The residues level fell below the maximum residue limit of 0.2 ppm within 15 days of treatment.

Similarly, samples collected at regular intervals from the trees treated with carbaryl (0.2%) were got analyzed. The samples collected on 0, 1, 3, 7, 14, 21 and 28 days after treatment were analyzed for the residues of the insecticides. The residues level fell below the maximum residue limit of 0.5 ppm within 21 days of treatment.

### 3.4 Evaluation of newer insecticides against tea mosquito bug (TMB)

#### 3.4.1 Evaluation of spray oil

Spray Oil supplied by M/s Indian Oil Corporation, Mumbai, was evaluated against TMB

under field condition. Three sprays were given at flushing, flowering and fruiting stages. Damage on shoots was assessed after one month of third spray in 0 - 4 scale. Spray oil at both 1 and 2 per cent concentration was inferior to recommended insecticide,  $\lambda$ -cyhalothrin (0.003%). The damage rating was in the range of 0.69-0.78 in spray oil treatment compared to 0.22 in  $\lambda$ -cyhalothrin.

#### 3.4.2 Efficacy of fenprothrin against TMB under field condition

Fenprothrin (Meothrin 30 EC) supplied by M/s. Sumitomo Chemical, India, Mumbai, was evaluated against TMB under field condition. Three sprays were given at flushing, flowering and fruiting stages. Damage on shoots was assessed after one month of third spray in 0-4 scale. The damage grade was recorded on 52 shoots in each tree and the mean damage was worked out. The damage rating in fenprothrin (0.02%) was on par with the recommended insecticide,  $\lambda$ -cyhalothrin (0.003%). The damage rating was 0.36 for fenprothrin and 0.22 for  $\lambda$ -cyhalothrin. In untreated check, the damage rating was 1.68. There was no significant difference in the natural enemy complex in the treated plots and untreated control. The mean number of predators/panicle ranged from 0.92 - 1.10 in the fenprothrin treated plots compared to 0.95 in the untreated control. In the laboratory confirmatory trial, the insecticide was found to induce 100 per cent mortality of both nymphs and adults of TMB suggesting the higher toxicity.



## 4. POST-HARVEST TECHNOLOGY

### 4.1 Bioavailability of minerals in cashew

Defatted cashew kernel flour of released varieties was prepared by extraction with n-hexane at ambient temperature over a period of five days. The defatted kernel flour (100mg) was digested separately for 2h at

220°C with diaacid (10 ml) (acid digestion) and proteolytic enzymes (enzyme digest). The digests were analysed for Fe, Cu, Mn, Zn and Se by AAS. The mineral content in the acid digest exhibited significant varietal variation (Table 4.1). Out of 35 varieties

**Table 4.1 : Mineral content of acid digest of defatted cashew kernel flour ( $\mu\text{g}/100 \text{ mg}$ ) (n=3)**

Variety	Fe	Cu	Zn	Mn	Se
Ullal-1	2.709	1.113	5.429	0.817	8.157
Ullal-2	2.166	1.385	5.292	0.414	3.089
Ullal-3	2.629	1.252	4.166	0.422	6.156
Ullal-4	3.432	1.498	5.606	0.833	ND
UN-50	3.024	1.094	5.215	0.697	ND
Chintamani-1	5.252	0.893	6.578	0.655	ND
V-1	5.73	0.629	1.953	0.851	2.64
V-2	6.021	0.955	4.079	1.657	3.188
V-3	8.633	0.966	4.883	1.893	1.344
V-4	4.813	0.839	4.959	2.058	2.714
V-5	6.13	0.935	5.414	2.21	10.834
V-6	4.05	0.909	5.309	1.312	2.63
V-7	10.656	2.384	2.306	0.822	4.573
NRCC Sel-1	8.909	2.307	2.132	1.446	2.189
NRCC Sel-2	15.056	2.55	1.723	1.411	3.22
Bhaskara	9.776	2.488	1.923	0.954	4.262
VRI-1	12.042	2.696	2.274	1.785	1.325
VRI-2	8.567	2.936	1.82	1.456	3.415
VRI-3	4.734	0.722	14.161	0.911	ND
BPP-1	3.966	0.915	19.107	1.692	ND
BPP-2	3.875	0.962	21.765	1.259	ND
BPP-5	4.218	1.147	20.137	1.695	ND
BPP-6	4.266	1.171	22.68	1.256	ND
Jhargram-1	3.723	0.834	19.893	1.504	ND
Bla-39-4	3.174	0.907	5.31	2.189	ND
Kanaka	3.23	2.884	4.865	1.314	ND
Dhana	3.727	3.352	5.612	1.135	ND
Akshaya	9.495	3.363	7.589	0.969	2.361
Dharashri	3.272	1.734	4.952	0.806	ND
Amrutha	8.716	2.224	2.245	1.452	2.547
Sulabha	10.712	2.461	2.54	1.376	4.179
Anagha	11.27	2.084	2.267	0.936	4.513
Priyanka	12.524	1.283	2.521	1.531	12.59
NDR-2-1	15.645	1.10	2.172	1.907	11.03
Bhubaneswar-1	2.302	1.877	5.379	1.395	11.512
CD (5%)	1.232	0.236	1.892	0.318	-

analysed Se was not detected in 13 varieties. The mineral content in the enzyme digest of defatted cashew kernel flour exhibited significant variation among the

released varieties (Table 4.2). Fe, Cu, Zn, Mn and Se were not detected in the enzyme digest of 6, 4, 21, 16 and 13 varieties respectively.

**Table 4.2: Mineral content of enzyme digest of defatted cashew kernel flour ( $\mu\text{g}/100 \text{ mg}$ ) (n=4)**

Variety	Fe	Cu	Zn	Mn	Se
Ullal-1	ND	0.282	ND	ND	7.089
Ullal-2	0.474	0.879	ND	ND	5.418
Ullal-3	1.242	0.189	0.112	0.171	9.288
Ullal-4	0.718	0.28	ND	0.06	0.815
UN-50	0.34	0.063	ND	ND	6.653
Chintamani-1	0.30	ND	1.331	ND	2.719
V-1	ND	0.247	ND	ND	4.662
V-2	ND	0.643	ND	ND	6.623
V-3	ND	0.097	ND	ND	3.337
V-4	0.461	0.247	ND	ND	2.236
V-5	0.573	0.286	ND	ND	5.748
V-6	0.439	0.065	ND	0.236	4.293
V-7	0.964	1.056	1.017	0.458	3.757
NRCC Sel-1	1.746	ND	0.875	0.821	ND
NRCC Sel-2	0.789	ND	0.409	0.705	4.297
Bhaskara	1.18	0.543	0.285	0.083	2.363
VRI-1	3.519	0.427	1.507	0.866	2.662
VRI-2	1.225	1.222	0.546	0.006	ND
VRI-3	2.736	0.552	ND	0.709	ND
BPP-1	0.942	0.382	2.896	0.33	ND
BPP-2	1.606	0.135	0.889	0.782	ND
BPP-5	2.45	0.15	3.232	1.063	ND
BPP-6	1.425	0.419	1.895	1.016	ND
Jhargram-1	0.982	0.361	1.50	0.258	ND
Bla-39-4	0.614	0.442	ND	ND	ND
Kanaka	0.934	0.711	0.819	0.507	ND
Dhana	1.442	1.246	ND	0.562	ND
Akshaya	1.676	0.405	ND	ND	5.64
Dharashri	0.164	0.412	ND	0.441	ND
Amrutha	0.904	ND	ND	ND	2.207
Sulabha	0.429	0.135	ND	ND	4.438
Anagha	ND	0.212	ND	ND	4.94
Priyanka	0.335	0.616	ND	ND	ND
NDR-2-1	0.513	0.533	ND	ND	1.82
Bhubaneswar-1	ND	0.462	ND	0.306	4.093
CD (5%)	0.819	0.206	0.682	0.329	-

Bioavailability of minerals of defatted cashew kernel flour exhibited variation among released varieties (Table 4.3). Bioavailability of all the five minerals (Fe, Cu, Zn, Mn and Se) was noticed in Ullal-

3, V-7, Bhaskara and VRI-1 although the per cent bioavailability differed for different minerals. Among the different varieties Zn and Mn were not bioavailable in 21 and 16 varieties respectively

**Table 4.3 : Bioavailability of minerals of defatted cashew kernel flour (%)**

Variety	Fe	Cu	Zn	Mn	Se
Ullal-1	0	25.3	0	0	86.9
Ullal-2	21.9	63.5	0	0	100
Ullal-3	47.2	15.1	2.7	40.5	100
Ullal-4	20.9	18.7	0	7.2	0*
UN-50	11.3	5.8	0	0	0*
Chintamani	5.7	0	20.2	0	0*
V-1	0	39.3	0	0	100
V-2	0	67.3	0	0	100
V-3	0	10.0	0	0	100
V-4	9.6	29.4	0	0	82.4
V-5	9.3	30.6	0	0	100
V-6	10.8	7.1	0	18.0	100
V-7	9.0	44.3	44.1	55.7	82.2
NRCC Sel-1	19.6	0	41.0	56.8	0
NRCC Sel-2	5.2	0	23.7	49.9	100
Bhaskara	12.1	21.8	14.8	8.7	55.4
VRI-1	29.2	15.8	66.3	48.5	100
VRI-2	14.3	41.6	30.0	0.4	0
VRI-3	57.8	76.4	0	77.8	0*
BPP-1	23.7	41.7	15.2	19.5	0*
BPP-2	41.4	14.0	4.1	62.1	0*
BPP-5	58.1	13.1	16.0	62.7	0*
BPP-6	33.4	35.7	8.4	80.9	0*
Jhargram-1	26.4	43.3	7.5	17.1	0*
Bla-39-4	19.3	48.7	0	0	0*
Kanaka	28.9	24.6	16.8	38.6	0*
Dhana	38.7	37.2	0	48.6	0*
Akshaya	17.6	12.0	0	0	100
Dharashri	5.0	23.8	0	54.7	0*
Amrutha	10.4	0	0	0	86.6
Sulabha	4.0	5.5	0	0	100
Anagha	0	10.2	0	0	100
Priyanka	2.7	48.0	0	0	0
NDR-2-1	3.3	48.4	0	0	16.5
Bhubaneswar-1	0	24.6	0	21.9	35.5

\* In these varieties Se was not detected in defatted cashew kernel flour

compared to Fe, Cu and Se.

Weightage was ascribed to bioavailability of minerals (Table 4.4) and an index for identifying variety with better bioavailability has been worked out (Table 4.5). Maximum index will be 50 while minimum will be 5. A variety with higher index indicated the better bioavailability of minerals compared to lower index. Bioavailability of all the minerals was noticed in Ullal-3, V-7, Bhaskara and VRI-1 with an index of 23, 26, 14 and 27 respectively. Bioavailability of Fe, Cu, Zn and Mn was noticed in

**Table 4.4 : Weightage ascribed for % bioavailability of minerals**

% Bioavailability	Weightage
0.1 – 10	1
10.1 – 20	2
20.1 – 30	3
30.1 – 40	4
40.1 – 50	5
50.1 – 60	6
60.1 – 70	7
70.1 – 80	8
80.1 – 90	9
90.1 – 100	10

**Table 4.5 : Index for bioavailability of minerals in defatted cashew kernel flour**

Variety	Fe	Cu	Zn	Mn	Se	Total
Ullal-1	-	3	-	-	9	12
Ullal-2	3	7	-	-	10	20
Ullal-3	5	2	1	5	10	23
Ullal-4	3	2	-	1	-	6
UN-50	2	1	-	-	-	3
Chintamani-1	1	-	3	-	-	4
V-1	-	4	-	-	10	14
V-2	-	7	-	-	10	17
V-3	-	1	-	-	10	11
V-4	1	3	-	-	9	13
V-5	1	4	-	-	10	15
V-6	2	1	-	2	10	15
V-7	1	5	5	6	9	26
NRCC Sel-1	2	-	5	6	-	13
NRCC Sel-2	1	-	3	5	10	19
Bhaskara	2	3	2	1	6	14
VRI-1	3	2	7	5	10	27
VRI-2	2	5	3	-	-	10
VRI-3	6	8	-	8	-	22
BPP-1	3	5	2	2	-	12
BPP-2	5	2	1	7	-	15
BPP-5	6	2	2	7	-	17
BPP-6	4	4	1	9	-	18
Jhargram-1	3	5	1	2	-	11
Bla-39-4	2	5	-	-	-	7
Kanaka	3	3	2	4	-	12
Dhana	4	4	-	5	-	13
Akshaya	2	2	-	-	10	14
Dharashri	1	3	-	6	--	10
Amrutha	2	-	-	-	9	11
Sulabha	1	1	-	-	10	12
Anagha	-	2	-	-	10	12
Priyanka	1	5	-	-	-	6
NDR-2-1	1	5	-	-	2	8
Bhubaneswar-1	-	3	-	3	4	10

BPP-1, BPP-2, BPP-5, BPP-6, Jhargram-1 and Kanaka with an index of 12, 15, 17, 18, 11 and 12 respectively. Varieties Ullal-3 and V-7 and VRI-1 are better compared to other varieties for bioavailability of Fe, Cu, Zn, Mn and Se.

## 4.2 Design development of artificial dryer for raw cashewnut

### 4.2.1 Preliminary studies on drying of raw cashewnuts

Preliminary studies conducted with raw cashewnuts of "Bhaskara" variety in convective air oven revealed that increase in air temperature decreases time required for drying. Loss of the volatile contents from raw cashewnuts was observed beyond air temperature of 60°C. More over, kernels turned scorched (discolouration) when it was exposed to higher temperature while drying. Time required to dry raw cashewnuts at air temperature of 60°C inside oven is in the range of 18 to 22h. whereas, drying time under sun is found to be in the range of 33 to 40 h.

### 4.2.2 Visit to north eastern hilly region of India

Cashew plantations and processing units in NEH regions were visited to work out the feasibility of developing a dryer for rain soaked nuts. Cashew production in NEH viz., (Assam (8.88%), Meghalaya (60.03%), Manipur (4.44%) and Tripura (26.26%) is around 11260 MT harvested from a total area of 13,987 ha. Most of the cashew plantations are raised with seedlings and production potential per unit area is well below national average. Delayed harvest coinciding with monsoon rains due to late flowering resulted in deterioration of the nut quality. Peak harvest is interrupted by heavy and incessant rains, affecting the quality of the nuts, fetching low price in the market. Good quality nuts which escape rain can fetch around Rs. 27 to Rs 30 per kg. Last harvest starts from June which sometime extends up to August accounting to 10 to 20 % of total harvest.

About 21 cashew processing units following drum roasting i.e. Assam (13 nos.), Meghalaya (5Nos.)

and Tripura (3 Nos.) constitute cashew processing sector in NEH region. Only 20 % of total production is processed by these processing units and remaining is exported to either Orissa or West Bengal. Most of the processing units are operating with lower efficiency which needs immediate attention.

### 4.3 Alternative use of cashew shell

Observation trials conducted at TNAU, Tamilnadu revealed that average calorific values of cashew shell and its cake with moisture content in the range of 2 to 3% d.b. as determined by bomb calorimeter was 5810 cal/g and 4403 cal/g respectively. The ash, volatile and fixed carbon contents were 7.8%, 19.9% and 70.6% respectively for cashew shell. The values were 13.3%, 26.0% and 57.4 % respectively for cashew shell cake. Producer gas generated from cashew shell cake was 1.35 sec g-1 with gas burning temperature in the range of 634 to 920°C using paddy husk gasifier coupled with gas cleaning system. Cashew shell could generate producer gas (0.96 sec /g.) with gas burning temperature of 984 to 1092°C.

Densification of cashew shell cake in its natural form without any adhesives was found to be difficult. While making briquettes using screw type press enormous amount of heat was liberated leading to burning of briquettes inside the press itself. Pulverised cashew shell cake blended with coir pith resulted stable briquettes, but alternative blending material (agricultural waste) is needed to improve calorific value of briquette.

### 4.4 Problem identification specific to cashewnut processing industries in Kerala State

Based on the survey conducted in Kerala state, certain problem areas have been identified which needs immediate attention. It includes, developing standards for raw cashewnuts, detection and discarding spoiled nuts before processing, comparative study on drum roasting and steam boiling methods of conditioning raw cashewnuts, development of compact type drum roasting system, developing highly mechanized shelling and peeling processes, machine system for kernel grading, studies on moisture dynamics in cashew kernels and energy budgeting in cashew industries.



## 5. TRANSFER OF TECHNOLOGY

### 5.1 Monitoring of demonstration plots

Existing demonstration plots laid out by NRCC on various aspects of cashew cultivation were monitored by a team of scientists and the technical advice was offered as and when required. During the year nine new demonstration plots were established on varieties, planting system, high density planting and soil and water conservation techniques. The newly selected demonstration farmers were trained on ICAR Foundation Day on various operations to be taken up for the establishment of cashew orchard. The planting material was distributed to the selected farmers.

### 5.2 Organizing training programmes

During the year one training programme each on softwood grafting of cashew and nursery management was organized for officials from forest departments of Goa and Gujarat states. A total of six officials underwent the training.

Another training programme on pruning in cashew and composting of recyclable cashew biomass was organized in which six officials from Goa and Assam participated. The trainees were trained on the techniques of pruning and top working, stem borer management and preparation of compost from recyclable cashew biomass.

A refresher course on Cashew Production Technology was organized during fruiting season of the year. In this training programme four officials from Assam and Goa and also a farmer participated. The programme was for three days in which the production technologies were discussed and demonstrated in the field.

A special training programme on Cashew Production Technology was organized for farmers of Bodoland Territorial Council of Assam, officials of Agriculture Department, Assam, BAIF, Gujarat and Maharashtra units and Forest Department of Goa during fruiting season. Besides theory and practical classes, the participants were also taken to progressive farmers' field, private nurseries, SKDRDP and Dharmasthala.

The training programmes on cashew apple

utilization were organized during April and May 2007. Two programmes were arranged for farm women in which 17 ladies each participated.

Another programme was arranged for 52 participants of 'Kappart' training programme organized by an NGO, The Nagarika Seva Trust, Guruvayanakere. In this programme both men and women participated. All these programmes had theory classes and practical demonstration of preparation of jam, squash, chutney and pickles.

Ten day long, training programmes on Cashew Production Technology were organized for the farmers sponsored by the Krishi Vigyana Kendra (KVK) of Central Plantation Crops Research Institute, Kasaragod. In this programme about 300 farmers were trained on various aspects of Cashew Production Technology.

### 5.3 Participation in exhibition

The centre participated in the following exhibitions

- (i) Horticultural Summit-cum-Exhibition 2007 at CISH, Lucknow during 16-18<sup>th</sup> June 2007.
- (ii) Food Expo 2007 organized by ICAR, New Delhi in connection with ICAR Foundation Day during 16-17<sup>th</sup> July 2007.
- (iii) International Horti-Expo 2008 at Pragathi Maidan, New Delhi between 30<sup>th</sup> and 2<sup>nd</sup> March 2008.
- (iv) CPCRI, Kasaragod during its Krishi Mela at Kasaragod during 19<sup>th</sup> May 2007.

### 5.4 Production and supply of planting material

During the year more than 2.5 lakh cashew grafts were produced in two nurseries of the Centre under three different schemes, Mega Seed Project, DCCD Revolving Fund and Institute nursery during the year 2006-07 and distributed to the farmers and development agencies.

### 5.5 Annual Cashew Day

The Annual Cashew Day of NRC for Cashew was held on 12<sup>th</sup> February 2008 at Kemminje campus of the Research Centre. The programme was sponsored by

Directorate Cashew and Cocoa Development (DCCD), Kochi, which was attended by about 350 farmers and other dignitaries. In the morning, the farmers were taken to Demonstration of Technology Developed (DTD) Plot, Soil and Water Conservation Plot, Rejuvenation Plot, Nursery, Museum (Exhibition) and Engineering Workshop to explain the different activities of the Research Centre. Later a seminar was organized on "Technologies for Organic Production of Cashew". The Chief Guest of the meeting, Mr. G. Giridhar Prabhu, CEO of Achal Industries, Mangalore expressed concern over the reduction in the share of India in the export of cashew. Sri. Anna Vinayachandra, a progressive farmer and former MLC stressed the need to attract domestic market of cashew rather than relying solely on export market. Sri. R.M.N. Sahai, Managing Director, Karnataka Cashew Development Corporation,

Mangalore felt that progress would be achieved in cashew production in view of financial assistance available to farmers under National Horticulture Mission. Sri. N. Achutha Moodathaya, a progressive farmer, felt that cashew production system should be brought under organic practices in a phased manner. Sri. A. Somanna, Senior Asst. Director of Horticulture, Puttur, explained about various activities and programmes available from the Dept. of Horticulture, Govt. of Karnataka, under National Horticulture Mission for the cashew farmers. Dr. N. Yadukumar, Principal Scientist (Agronomy) delivered a lecture on organic farming in cashew. Dr. M.G. Bhat, Director of NRCC, who presided over the meeting, informed about the availability of extension literatures and training programmes on cashew for the benefit of cashew farmers.



## 6. CONCLUDED PROJECTS

### 6.1 Evaluation of cashew hybrids for the improvement of nut size in released varieties (XII A and B) (Two experiments concluded under Project 1.2, Varietal Improvement of Cashew)

Project Leader Dr. P. M. Kumaran (1991-1994)  
Dr. Thimmappaiah (1991-1994)  
Dr. M. G. Bhat (1994-2005)  
Dr. M. G. Nayak (2005- 2007)  
Dr. J. D. Adiga (2007- 2008)

Project Number 1.2  
Project Duration 1991 - 2008

#### 6.1.1 Introduction

In cashew, nut size enhances the export potential. One of the approaches to improve the nut size of released varieties is through hybridization. Since most of the released varieties had lower nut weight (< 7g) an attempt was made to improve the nut size in such varieties by crossing with bold nut types.

#### 6.1.2 Objectives

- Improvement of the nut size in released varieties.
- Studying the consequences of hybridization on yield and yield related parameters (nut weight, kernel weight and shelling percentage).

#### 6.1.3 Treatments

#### Expt. XII A : Evaluation of cashew hybrids for the improvement of nut size in released varieties

No. of crosses : 6+1 self

- M44/3 x VTH 40/1
- BLA 139-1 x VTH 711/4
- V 5 x VTH 711/4
- BLA 139-1 x VTH 40/1
- M 44/3 x VTH 711/4
- V 5 Self
- V 5 x Sel -2 (40/1)

Year of planting : 1991 and 1992  
Location : Kemminje  
Design : Unreplicated  
Plot size : Individual trees  
No. of experimental plants : 310  
No. of border plants : 3  
Total no. of plants : 313

#### Expt. XII B Evaluation of cashew hybrids for the improvement of nut size in released varieties

No. of crosses : 16+4 + 1

- VRI 2 x VTH 40/1
- BLA 139-1 x VTH 711/4
- V 5 x VTH 711/4
- BLA 139-1 x VTH 40/1
- V 5 x VTH 40/1
- V 5 x A. *pumilum*
- Inter sp. Hybrid
- (V5 x A. *pumilum*) x V5
- Inter sp. Hybrid
- (V5 x A. *pumilum*) x NRC 2
- Purple (OP)
- Purple x VTH 711/4
- BLA 139-1 x Purple
- BLA 139-1 (Tr No.18) x V 2
- BLA 139-1(Tr No. 19)x V2
- Panama (OP)
- Kavu ( OP )
- BLA 139-1 (Tr No. 18) x VTH 711/4
- BLA 139-1 (Tr No. 19) x VTH 711/4
- BLA 139-1 (Tr No. 269) x VTH 711/4
- V 2 x VTH 711/4
- VTH 711/4 (OP)
- Goa 11/6

Year of planting : 1993, 1994, and 1995  
Location : Kemminje  
Design : Un replicated  
Plot size : Individual trees  
No. of experimental plants : 287  
No. of border plants (Goa 11/6) : 5  
Total no. of plants : 292

## 6.1.4 Results and Discussion

### 6.1.4.1 Evaluation of cashew hybrids for the improvement of nut size in released varieties (Expt. XII A)

Among the different cross combinations, the tree no. 1250 of cross combination M 44/3 x VTH 40/1 performed better over the years with respect to mean yield (4.84kg), mean nut weight (7.62 g), kernel weight (2.2 g), and shelling percentage (29.41). Hence, tree no. 1250 has been carried forward for further evaluation in a replicated trial. The other combinations

were not satisfactory with respect to overall performance and hence were not carried forward for further evaluation (Table 6.1).

### 6.1.4.2 : Evaluation of cashew hybrids for the improvement of nut size in released varieties (Expt. XII B)

Among the different cross combinations, none of the hybrids performed satisfactorily with respect to different economical characters over the years (Table 6.2). Since none of the hybrids performed well with respect to overall performance, hybrids were not carried forward for further evaluation.

**Table 6.1 : Evaluation of cashew hybrids for the improvement of nut size in released varieties**

Cross Combination	Tree no.	Annual yield 2007 (kg/tree)	Cumulative yield (kg/tree)	No. of harvests	Mean cumulative yield (kg/tree)	Mean nut weight (g)	Kernel weight (g)	Shelling (%)
M44/3xVTH40/1	1250	3.00	58.12	12	4.84	7.62	2.20	29.41
BLA139-1xVTH711/4	1226	0.95	18.45	12	1.54	8.04	2.50	32.14
V5xVTH711/4	1242	3.10	28.98	10	2.89	7.50	2.06	28.69
BLA139-1xVTH40/1	1432	0.70	11.70	7	1.67	4.50	1.00	22.22
M 44/3 x VTH 711/4	1374	1.00	31.50	9	3.50	4.80	1.74	36.25
V 5 Self	1201	0.40	0.40	1	0.40	7.93	2.60	32.80
V 5 x Sel -2 (40/1)	1337	1.80	28.23	12	2.35	5.00	1.60	32.00

**Table 6.2 : Evaluation of cashew hybrids for the improvement of nut size in released varieties.**

Cross Combination	Tree no.	Annual yield 2007 (kg/tree)	Cumulative yield (kg/tree)	No. of harvests	Mean cumulative yield (kg/tree)	Mean nut weight (g)	Kernel weight (g)	Shelling (%)
VRI 2 x VTH 40/1	1595	3.70	21.59	9	2.39	5.63	1.72	30.64
BLA139-1xVTH711/4	1555	2.30	9.48	7	1.35	8.60	2.20	25.82
V5xVTH711/4	1634	2.00	17.94	8	2.24	6.33	1.87	29.47
BLA139-1xVTH40/1	1659	1.55	21.89	9	2.43	8.12	2.44	30.00
V5xVTH 40/1	1700	1.95	19.81	8	2.47	7.25	2.00	27.59
V5x <i>A. pumilum</i>	1563	0.45	10.77	9	1.19	6.43	1.79	27.78
Inter sp. Hybrid (V5 x <i>A. pumilum</i> ) X V5	1520	Gap	26.45	10	2.64	3.83	1.23	32.17
Inter sp. Hybrid (V5 x <i>A. pumilum</i> ) X NRC 2	1514	Gap	3.71	6	0.62	4.00	1.40	35.00
Purple(OP)	1760	Gap	1.60	1	1.60	NA	NA	NA
PurplexVTH711/4	1742	1.20	21.87	7	3.12	7.50	2.30	30.67
BLA 139-1 x Purple	1738	2.00	17.08	6	2.85	5.83	1.67	28.57
BLA 139-1(Tr No. 18) x V 2	1763	Gap	4.17	3	1.39	6.50	1.80	27.69
BLA139-1(TrNo.19)x V 2	1717	1.20	20.53	5	4.10	7.50	2.00	26.67
Panama (OP)	Gap	Gap	Gap	Gap	Gap	Gap	Gap	Gap
Kavu	Gap	Gap	5.36	3	1.78	10.50	3.00	28.57
BLA 139-1 (Tr No. 18) x VTH 711/4	Gap	Gap	5.78	4	1.44	9.00	2.20	24.44
BLA 139-1 (Tr No. 19) x VTH 711/4	1712	1.10	9.90	6	1.65	7.50	2.50	33.33
BLA 139-1 (Tr No. 269) x VTH 711/4	1728	1.85	13.95	6	2.33	10.00	2.50	25.00
V 2 x VTH 711/4	1749	Gap	13.68	5	2.74	9.00	2.40	26.67
VTH 711/4 (OP)	1710A	Gap	2.70	1	2.70	NA	NA	NA
Goa 11/6	1766	Gap	9.15	5	1.83	10.00	2.60	26.00

### 6.1.5 Conclusions

The tree no. 1250 of cross combination M 44/3 x VTH 40/1 performed better over the years for mean yield ( 4.84kg), mean nut weight ( 7.62 g ), kernel weight ( 2.20 g ), and shelling percentage ( 29.41 ).

### 6.2: Green manuring in cashew to increase productivity of cashew

Project Leader : Dr. N. Yadukumar (2001 – 2008)  
 Project Associate : Dr. (Mrs) R. Rejani (2005 – 2008)  
 Project Number : NATP / 2.13  
 Project Duration : 2001 to 2003 under NATP and 2005 to 2008 under Institute project

#### 6.2.1 Introduction

Cashew is normally planted in hillocks, which are totally dry and unsuitable for the cultivation of any other plantation crops and the availability of moisture and nutrients are restricted. Green manure can provide benefits for the soil, crop and animals by increasing organic matter, earthworms and beneficial microorganisms and soil's available N, moisture retention; stabilizing the soil to prevent erosion; bringing deep minerals to the surface and breaking up hardpans; providing habitat, nectar and pollen for beneficial insects and reducing populations of pests, improving water, root and air penetration in the soil and smothering weeds.



Glyricidia as green manuring crop in cashew garden

#### 6.2.2 Objectives

Developing a viable method for generating green biomass to enrich nutrient content of the soil in cashew garden.

#### 6.2.3 Materials and methods

Cashew with four green manuring crops was planted out with the following five treatments namely:(i) cashew with sunhemp, (ii) cashew with sesbania, (iii) cashew with glyricidia (iv) cashew with cover crop (*Calapagonia muconoides*) and (v) cashew alone. This experiment was started in 2001 and is continued upto 2008. Both main and green manure crops were raised in 2001 and green manure crops like sunhemp and sesbania were sown every year. Glyricidia, being perennial, seeds were sown in 2001 and three cuttings per year were given. Four green manure crops were grown in between two rows of cashew planted at 4m x 4m distance. The control plot was maintained by growing cashew alone (without any green manure crop). These treatments were replicated four times and laid out by adopting RBD. Green biomass production was estimated and collected green biomass was applied back to the plot to improve the soil fertility. Soil samples were analysed for moisture and nutrient contents. Cashew leaf samples were also analyzed for nutrient contents.



Cashew with cover crop

## 6.2.4 Results and Discussion

### 6.2.4.1 Dry matter production of green biomass

Dry matter production of green biomass obtained from glyricidia was 7.65 t/ha/year whereas, it was 2.25 and 1.63 t/ha/year from sesbania, sunhemp and cover crop respectively (Table 6.3). Green biomass produced from glyricidia increased over the years whereas, in sesbania and other crops, it decreased due to the effect of shade resulted from increase in canopy area of cashew. In long run, glyricidia is the more useful green manuring crop for cashew garden.

### 6.2.4.2 Determination of soil moisture content in green manuring treatments

During January 2008, the soil moisture content was highest in cashew garden with glyricidia as green manuring crop (17.0 % to 18.6 % dry basis) compared to sunhemp (17.8 to 18.3 % dry basis), sesbania (15.5 to 18.2 % dry basis), cover crop (14.7 to 17.4 % dry basis) and control (15.5% to 17.0 % dry basis). During February also, the highest soil moisture content of 13.4% to 13.9% dry basis was observed in glyricidia plot compared to sunhemp (11.3 to 13.3%), sesbania (10.5 to

12.0% db), cover crop (10.3 to 11.8 % dry basis) and control plot (10.1 to 10.9% db). The mean soil moisture in glyricidia plot was 1.5% dry basis and 3.3% dry basis more than the control plot in January and February.

### 6.2.4.3 Nutrient content of the soil and leaf in green manuring treatments

Most of the major and minor nutrients present in the soil were highest in glyricidia plot compared to sunhemp, sesbania and cover crop (*Calapagonium muconoides*) and cashew alone (control). The organic carbon content (OC%) was highest (0.98%) in plot with glyricidia, 0.66% in plot with sunhemp and lowest (0.50%) in control with cashew alone. Similarly, the content of P<sub>2</sub>O<sub>5</sub> was highest (23.6 kg/ha) in plot with glyricidia and 9.1 kg/ha in control. The K<sub>2</sub>O content was highest in sesbania plot (162.3 kg/ha), then in sunhemp plot (141.1 kg/ha), glyricidia plot (126.2 kg/ha) and lowest in control (105.4 kg/ha) (Table 6.4). Highest Mg (glyricidia - 30.3 kg/ha and control -14.67 kg/ha), Cu (glyricidia- 1.43 ppm and control -0.78 ppm), Fe (glyricidia – 82 ppm and control -51 ppm), and Mn contents (glyricidia- 12.5 ppm and control – 5.7 ppm) was also observed in plot with glyricidia as

**Table 6.3 : Dry weight of green biomass yield of green manure crops in cashew garden (t/ha)**

Green manure crop	2002	2003	2004	2005	Mean yield
Sunhemp	3	3	2	1	2.25
Sesbania	6	8	5	4	5.75
Glyricidia	1.5	10	9	10	7.65
Cover crop	1	2	2	1.5	1.63

**Table 6.4 : Effect of green manure crops on major nutrient contents of soil and microbial biomass in cashew plantation**

Green manure crop	OC (%)	N (kg/ha)	P <sub>2</sub> O <sub>5</sub> (kg/ha)	K <sub>2</sub> O (kg/ha)	Microbial biomass-( $\mu$ g c/g soil )
Sunhemp	0.66	124	11.5	141.1	261
Sesbania	0.62	141	17.9	162.3	168
Glyricidia	0.98	186	23.6	126.2	229
Cover crop	0.59	87	20.9	97.0	149
No GM	0.50	76	9.1	105.4	160
CD (p=0.05)	0.19	7.49	1.56	1.77	

green manuring crop compared to control and all other green manuring crops. The Zinc content was highest in plot with sunhemp (36.9 ppm) and sesbania (34.8 ppm) compared to plot with glyricidia (27.87 ppm) as green manuring crop and control (20.22 ppm) (Table 6.5).

Beneficial micro organisms in terms of microbial biomass produced is also high in glyricidia plot (229  $\mu\text{g c/g}$  soil) next to sunhemp plot ( 261  $\mu\text{g c/g}$  soil) (Table 6.4). The green manure crop glyricidia contributed 186 kg N, 23.6 kg  $\text{P}_2\text{O}_5$  and 126.2 kg  $\text{K}_2\text{O}$ /ha and sesbania contributed 141 kg N, 17.9 kg  $\text{P}_2\text{O}_5$  and 162.3 kg  $\text{K}_2\text{O}$  per ha. Nutrient concentrations in leaf of cashew were highest in plot with glyricidia and cover crops (N-1.88 and 1.97%, P – 0.28 and 0.40 %, K - 0.51 and 0.54 %) compared other plots (Table 6.6).

#### 6.2.4.4 Yield of cashew

The yield of cashew was highest in plots where sesbania and glyricidia were grown as green manuring crop (Table 6.7). Cashew yield increased significantly in plot with glyricidia as green manuring crop (543 kg/ha in 2004, 845 kg/ha in 2005, 1048 kg/ha in 2006, 2123 kg/ha in 2007) compared to sesbania (794 kg/ha in 2004, 856 kg/ha in 2005, 925 kg/ha in 2006, 1987 kg/ha in 2007), other green manuring crops and control (400 kg/ha in 2004, 504 kg/ha in 2005, 845 kg/ha in 2006, 1290 kg/ha in 2007). Even though, the cashew yield was high in sesbania plot initially (2004 and 2005), in the long run, glyricidia as green manure crop for cashew is more beneficial than sesbania.

**Table 6.5 : Effect of green manure crops on minor and micronutrient contents of soil in cashew plantation**

Green manure crop	Mg (kg/ha)	Fe (ppm)	Cu (ppm)	Mn (ppm)	Zn (ppm)
Sunhemp	16.4	65.7	1.06	6.4	36.90
Sesbania	16.4	62.4	0.85	7.0	34.85
Glyricidia	30.3	82.0	1.43	12.5	22.87
Cover crop	15.6	54.0	0.86	6.1	23.87
No GM	14.6	50.9	0.78	5.7	20.22
CD (p=0.05)	1.98	6.4	0.22	1.2	2.5

**Table 6.6 : Effect of growing green manure crops on leaf nutrient centents (%)**

Treatment	N	P	K	Ca	Mg
Sunhemp	1.61	0.25	0.48	0.40	0.20
Sesbania	1.79	0.35	0.47	0.43	0.20
Glyricidia	1.88	0.28	0.51	0.46	0.20
Cover crop	1.97	0.40	0.54	0.58	0.20
CD (p=0.05)	0.336	0.066	0.105	0.081	0.06

**Table 6.7 : Effect green manure crops on cashew yield (kg/ha) over years**

Treatment	2004	2005	2006	2007	Cumulative yield of 4 years
Cashew+Sunhemp	469	658	820	2102	4049
Cashew +Sesbania	794	856	925	1987	4562
Cashew +Glyricidia	543	845	1048	2123	4558
Cashew +Cover crop	509	640	879	1678	3706
Cashew alone	400	504	845	1290	3039
Mean	543	701	903	1836	3983
SED					47
CD (p=0.05)					102

#### 6.2.4.5 Economics

The cost of cultivation was highest for sesbania (Rs.41617/ha) and sunhemp (Rs.40988/ha) as green manuring crop compared to cover crop (Rs.38613/ha), glyricidia (Rs.38113/ha) and control (Rs.32613/ha) (Table 6.8). Maximum profit of Rs.1,21,434/ha was obtained from plot with glyricidia as green manuring crop in cashew garden compared to sesbania (profit of Rs. 1,18,060/ha), sunhemp (profit of Rs.1,00,699/ha), cover crop (profit of Rs.81,313/ha) and control with a profit of Rs.83,570/ha (Table 6.9).

#### 6.2.5 Conclusions

Glyricidia can be effectively and profitably grown in between two rows of cashew as green manuring crops to improve the soil moisture content and soil fertility and to increase the cashew yield. The dry matter production of green biomass from glyricidia was 7.65 t/ha/year whereas, it was 5.75, 2.25 and 1.63 t/ha/year from sesbania, sunhemp and cover crop respectively. Soil organic carbon content and other also highest in plot where glyricidia and cover crops were grown with cashew. Maximum profit of Rs.1,21,434/ha was obtained from plot with glyricidia as green manuring crop in cashew garden compared to sesbania (profit of Rs. 1,18,060/ha), sunhemp (profit of Rs.1,00,699/ha), cover crop (profit of Rs.81,313/ha) and control with a profit of Rs.83,570/ha. Hence, in

long run, glyricidia is the more useful green manuring crop for cashew garden.

### 6.3 Nutraceuticals for health and specialty foods through biotechnology approaches

Project Leader Dr. K.V.Nagaraja  
Project Number DBT  
Project Duration 17 February 2005 to 16 February 2008

#### 6.3.1 Introduction

Nutraceuticals are assuming importance in recent years because of their health benefits. Cashew kernel, apple, testa and shell of released varieties have been biochemically characterized. Large variability for colour and various other biochemical constituents has been noticed among the released varieties. As cashew apple contains number of biochemical constituents which play a vital role in human health, the project on characterization of nutraceuticals from cashew apple was initiated in collaboration with Central Food Technological Research Institute, Mysore under DBT during 2005.

#### 6.3.2 Objectives

The major objectives were to isolate and characterize nutraceuticals from cashew apple with a long term objective of developing food products rich in fibre and antioxidants.

**Table 6.8 : Cost of cultivation for each treatment**

Cultural Practice	Treatment				
	Cashew + Sunhemp	Cashew+ Sesbania	Cashew+ Glyricidia	Cashew+ Covercrop	Cashew alone
Base clearing	13575	13575	13575	13575	13575
Weeding in interspaces	9350	9350	9350	9350	9350
Sowing seeds of green manure crops	9000	9000	5500	6000	-
Plant protection	2500	3125	3125	3125	3125
Picking of nuts	6563	6563	6563	6563	6563
Total	40988	41617	38113	38613	32613

**Table 6.9 : Economics of growing green manure crops in cashew garden (Rs. / ha)**

Treatments	Cost of cultivation	Income	Profit	Yield (kg/ha)
Cashew+Sunhemp	40988	1,41,687	1,00,699	4048
Cashew +Sesbania	41617	1,59,677	1,18,060	4562
Cashew +Glyricidia	38113	1,59,546	1,21,434	4558
Cashew +Cover crop	38613	1,19,926	81,313	3426
Cashew alone	32613	1,16,183	83,570	3320
Mean	38389	139404	101015	3983
CD (5%)		28,200	27,900	797

### 6.3.3 Results and Discussion

Fully mature cashew apples harvested from the plantations maintained at National Research Centre for Cashew were washed thoroughly with water, sliced and sun dried for 5 days (8h/day). After solar drying for 5 days, cashew apple slices were still leathery and hence they had to be dried for 2 to 3 days in a cabinet dryer at 70°C. Dried cashew apple slices were powdered and sieved through 60 mesh sieve.

Alternately, cashew apples after washing were autoclaved at 16 lbs for 10 min. Autoclaved cashew apples were sliced and dried at 70°C in a cabinet dryer for 2 to 3 days. Dried cashew apple slices were powdered and sieved through 60 mesh sieve.

Crude fibre from cashew apple powder was extracted by boiling for 30 min sequentially with sulphuric acid and sodium hydroxide followed by washing with distilled water, ethyl alcohol and diethyl

ether. The crude fibre thus extracted was dried at 70°C. The crude fibre content in cashew apple powder of different released varieties varied from 1.99 and 4.7%. Chintamani-1 had highest crude fibre content (4.7%) while "Sulabha" had lowest crude fibre content (1.99%) among the varieties analysed.

Ascorbic acid in the dried cashew apple powder of released varieties was analysed by extracting with oxalic acid and titrating against dichlorophenol indophenol. The ascorbic acid content among different varieties varied between 40.05 (Ullal-2) and 177.77 (UN-50) µg/100 mg powder.

The in vitro digestibility of crude fibre extracted from different varieties by diastase (Himedia) was studied. In vitro digestibility of crude fibre by diastase varied from 0.227 (Goa 1) to 1.515 (Ullal-2) mg maltose/3h/100 mg (Table 6.10).

**Table 6.10 : Composition of cashew apple powder (n=3)**

Source	Variety	Crude fibre (%)	Vitamin C (µg/100 mg)	In vitro digestibility of crude fibre *
NRCC (Kemminje)	BPP-1	3.59	71.48	0.667
	BPP-4	3.46	73.38	0.469
	BPP-5	3.51	102.65	0.602
	BPP-6	3.15	86.74	0.750
	VRI-3	2.68	65.22	0.379
	V-2	2.53	77.56	0.278
	Goa 1	3.24	92.89	0.227
	NRCC Sel-2	2.82	103.68	0.921
	NRCC Sel-1	3.29	96.01	0.641
	Bhubaneswar-1	2.39	45.73	0.543
	Jhargram-1	2.97	115.42	0.238
	Ullal-2	2.85	76.07	1.514
	Ullal-4	2.59	77.59	0.660
	K-22-1	3.29	85.22	0.385
	Dhana	3.08	105.85	0.339
	Priyanka	4.35	115.75	0.510
	Bla 39-4	3.59	60.53	1.407
	Kanaka	2.88	52.88	0.550
UN-50	2.65	177.77	0.554	
Ullal-2	3.83	40.05	0.898	
NRCC (Shantigodu)	Ullal-1	3.55	62.09	0.617
	Ullal-3	3.25	84.50	0.462
	Chintamani-1	4.70	93.27	0.560
	NDR-2-1	2.44	99.92	0.635
	VRI-1	3.39	99.76	0.516
	V-1	3.44	89.36	0.340
	Sulabha	1.99	47.47	0.354
	Bhaskara	3.43	58.02	0.334
Bulk	Yellow	2.57	115.31	2.714
	Red	2.88	98.34	1.35
	Autoclaved and dried	3.92	161.65	3.56

\* Expressed as mg maltose released/3h/100 mg fibre

Solar dried cashew apple powder of released varieties were analysed for tannin, carotenoids and anthocyanin pigments. Significant variation among different varieties was noticed. The variability among released varieties noticed is presented in Table 6.11. Alternatively, cashew apple powder of released varieties was soxhlet extracted with methanol and tannin and phenols contents after treatment with ion exchange resins were analysed and variability noticed is presented in Table 6.12. Extractability of protein from cashew apple powder with different solvents was studied and 0.05 N NaOH extracted maximum quantity of proteins compared to water and 0.25 M NaCl.

Varietal variation was noticed in the protein content. Variability noticed is presented in Table 6.13. Although, variety Chintamani-1 had highest protein content, its extractability was less compared to Jhargram-1 whose protein content was 6.91%.

Antioxidant properties of the methanol extract of solar dried cashew apple powder of released varieties were assessed. Variability observed for the antioxidant activities is presented in Table 6.14. Significant variation among released varieties was observed for antioxidant activities and phenols content. Higher antioxidant activity appears to be associated with higher phenols contents.

**Table 6.11 : Variability among released varieties for tannin, carotenoids and anthocyanin**

Tannin (mg/100 mg)	0.267 (Sulabha) - 2.341 (BPP-2)
Carotenoids (mg/100 mg)	0.08 (Ullal-3) - 0.482 (UN-50)
Anthocyanin (OD units/g)	11.78 (Ullal-3) - 65.92 (UN-50)

**Table 6.12 : Variability among released varieties for tannin and phenols in soxhlet extracted methanol extracts**

Tannin (mg/100 mg)	0.197 (Anagha) - 0.674 (Sulabha)
Phenols ( $\mu$ g/100 mg)	17.24 (Madakkathara-1) - 52.5 (Kanaka)

**Table 6.13 : Variability for protein content and its extractability among different released varieties**

Protein (mg/100 mg)	4.26 (BPP-4) - 12.29 (Chintamani-1)
Extractability (mg/100 mg)	
Distilled water	0.122 (Kanaka) - 0.549 (Jhargram-1)
0.25 M NaCl	0.082 (Ullal-3) - 0.483 (Jhargram-1)
0.05 N NaOH	0.8 (BLA-39-4) - 2.09 (Jhargram-1)

**Table 6.14 : Variability for antioxidant activity in methanol extract of sundried cashew apple powder**

DPPH scavenging activity ( $\mu$ mols/15 min/100 mg)	0.58 (BPP-4) - 2.861 (NDR-2-1)
Reducing powder ( $A_{700}$ / 20 min / 100 mg)	19.14 (Ullal-2) - 51.98 (NDR-2-1)
Total phenols ( $\mu$ g/100 mg)	36.07 (Chintamani-1) - 269.58 (NDR-2-1)

Cashew apple powder prepared by autoclaving and drying of released varieties was extracted with methanol by soxhlet and antioxidant activities in the methanolic extract and different fractions such as amino acids, sugars and phenols obtained after treatment with ion exchange resins were determined. The variability among the released varieties is presented in Table 6.15. Varieties Dhana, Ullal-1, Ullal-4, Dharasri, Chintamani-1 and Amrutha exhibited higher antioxidant activities of either methanol extract or different fractions.

In an attempt to prepare fibre and antioxidant rich cereal flour blends, cashew apple powder prepared under different conditions was blended at concentration ranging between 5 and 20% with rice, ragi and wheat flours and antioxidant properties were assessed.

DPPH scavenging activity in methanol extract and phenols fractions increased with increased concentration of cashew apple powder. Rice flour exhibited lowest DPPH activity (0.033) compared to

wheat (0.05) and ragi (0.429). DPPH scavenging activity in sugars and amino acid fractions was not detected.

Similarly Potassium Ferricyanide reduction activity in the methanol extract and fractions (sugars, amino acids and phenols) increased with increased concentration of cashew apple powder.

The hydrogen peroxide scavenging activity of methanol extract, amino acids, sugars, and phenols fractions obtained after treating with ion exchange resins of cashew apple powder of released varieties was determined. Significant varietal variation was observed. The variability observed among varieties is presented in Tables 6.16 and 6.17. Compared to methanol extract, scavenging activity in different fractions is less indicating the possibility of loss during treatment with ion exchange resins. Tannin in the methanol extract, amino acid, reducing sugar and phenols in the respective fractions were estimated and scavenging activity expressed /mg of these fractions is high. Varietal variation was noticed for these constituents also.

**Table 6.15 : Variability for antioxidant activities in methanol extract (soxhelt extracted) and different fractions for autoclaved and dried cashew apple powder**

DPPH activity ( $\mu\text{mols}/15 \text{ min}/100 \text{ mg}$ )			
Methanol extract	1.431 (BPP-4)	-	2.804 (Dhana)
Amino acid fraction	0.566 (V-4)	-	1.38 (Ullal-1, Ullal-4)
Sugar fraction*	0.052 (Kanaka)	-	1.035 (Dharasri)
Phenols fraction	0.008 (BPP-4)	-	0.2 (Chintamani-1)
Reducing powder ( $A_{700} / 20 \text{ min} / 100 \text{ mg}$ )			
Methanol extract	30.87 (BPP-6)	-	56.47 (Amrutha)
Amino acid fraction	4.52 (BPP-5)	-	15.23 (Ullal-1)
Sugar fraction*	1.105 (V-4)	-	4.63 (Ullal-1)
Phenols fraction	0.711 (NRCC Sel-2)	-	2.64 (V-3)

\* Activity not detected in few varieties

**Table 6.16 : Variability of  $\text{H}_2\text{O}_2$  scavenging activity in methanol extract and different fractions of cashew apple powder of released varieties of cashew. (mmoles scavenged/10min/100mg)**

Methanol Extract	1.9 (Anagha)-8.63 (V-4)
Amino acid Fraction	0.24 (Bhubaneswar 1)-1.38 (Kanaka)
Sugar Fraction	0.08 (Madakkathara 1)-0.76 (Sulabha)
Phenols Fraction	0.14 (Chintamani 1)-0.76 (Sel 2)

**Table 6.17 : Variability of tannin, aminoacid, reducing sugars & phenols in methanol extract & different fractions of cashew apple powder of released varieties**

Tannin (mg/100mg)	0.2 (BPP 5)-0.57(V 3)
Amino acid (mg/100mg)	0.16 ( Anagha)-1.98 (V 1)
Reducing Sugar(mg/100mg)	3.56 (V 5)-24.83(Amrutha)
Phenols Fraction (ug/100mg)	8.42 (V-7)-61.17(Sel 1)

Studies on storage of cashew apple powder prepared under different conditions have indicated that moisture content (4-13%) and peroxides (4-16) tend to increase while, ascorbic acid, phenols, amino acid and reducing sugars tend to decrease during storage upto 12 months at ambient temperature. However, the tannin content in cashew apple powder did not change much during storage at ambient temperature. Increase in peroxides during storage was less in cashew apple powder prepared after treatment with salt and KMS

(Table 6.18). Antioxidant activity in methanol extract, amino acids, phenols fraction and 0.4% oxalic acid extract of cashew apple powder during storage at ambient temperature is presented in Table 6.19 and 6.20. DPPH scavenging activity did not change upto 4 months beyond which the activity decreased. Reducing powder decreased gradually during storage. Results indicate that cashew apple powder could be stored upto 4 months without any loss of antioxidant activity.

**Table 6.18 : Biochemical changes during storage of CAP at ambient temperature (27-30°C) (n=3)**

Sample	Storage period (Days)	Moisture, %	Ascorbic acid, µg/100 mg	Tannin, µg/100 mg	Phenols, µg/100 mg	Reducing sugars, %	Amino acids, %	Peroxides, n mols *MDA/ 100 mg
CAP, A	0	4.84	83.19	310.67	87.79	14.34	19.86	4.46
	2	5.51	74.77	358.90	92.47	18.38	3.93	4.46
	4	2.94	48.92	220.10	41.78	18.58	2.14	4.10
	6	3.99	41.15	238.97	19.94	17.65	1.04	4.58
	8	8.98	31.91	224.28	27.55	11.72	2.04	6.82
	10	10.60	19.06	203.39	28.77	11.74	0.47	10.51
	12	13.11	20.74	311.00	34.21	17.54	1.66	16.23
	CD, 5%	0.34	5.80	47.93	11.92	4.31	1.36	1.72
CAP, B	0	4.18	137.02	257.05	87.26	16.63	24.53	4.6
	2	4.62	108.75	341.05	95.45	18.78	3.82	4.04
	4	2.33	63.65	183.2	47.79	22.60	1.12	4.17
	6	3.63	51.2	197.37	13.46	19.96	0.45	10.19
	8	9.05	31.56	175.97	32.58	6.44	0.96	7.47
	10	11.25	18.00	342.91	27.11	15.13	0.74	11.04
	12	13.78	21.63	253.0	32.98	16.17	1.15	15.74
	CD, 5%	0.49	8.05	24.10	3.98	3.71	3.9	2.13
CAP, C	0	3.64	168.35	187.14	66.14	9.05	16.36	1.79
	2	3.72	135.14	356.5	67.35	10.79	3.53	1.98
	4	2.43	78.44	124.0	41.92	10.76	2.02	1.56
	6	2.95	58.61	60.96	13.52	9.52	1.58	3.96
	8	5.91	32.06	32.92	70.24	13.71	3.54	2.91
	10	7.39	19.02	187.74	25.45	9.67	5.38	3.05
	12	9.05	13.93	252.0	22.26	9.67	1.31	6.22
	CD, 5%	0.30	6.15	30.36	15.39	2.92	2.12	0.87
CAP, D	0	2.56	75.09	240.18	52.95	8.0	10.20	2.35
	2	2.99	65.38	298.7	70.87	11.67	3.46	2.39
	4	1.33	35.38	152.0	41.92	10.41	3.16	2.29
	6	3.21	33.04	83.8	13.49	7.93	1.34	6.29
	8	5.93	28.19	45.95	26.06	7.89	1.59	4.33
	10	7.59	21.42	61.90	23.71	8.69	2.87	5.70
	12	9.85	13.98	228.0	25.46	6.88	1.37	8.30
	CD, 5%	0.53	4.61	25.86	2.82	2.01	1.31	1.43

\*MDA – Malonic dialdehyde;

A - CAP prepared from red apple by autoclaving and drying; B – CAP prepared from yellow apple by autoclaving and drying; C – CAP prepared from yellow apple after treatment with NaCl and Potassium bisulphite and autoclaving and drying; D – CAP prepared from yellow apple after treatment with NaCl and Potassium bisulphite; E – CAP prepared from solar dried yellow apples; F – CAP prepared from solar dried red apples

**Table 6.19 : DPPH scavenging activities of CAP during storage at ambient temperature (27-30°C)(n=3)**

Sample	Storage period (Days)	DPPH scavenging activity, $\mu$ mols/15 min/100 mg			
		Methanol extract	Amino acids fraction	Phenols fraction	0.4% oxalic acid extract, ascorbic acid fraction
CAP, A	0	2.03	1.02	0.15	1.88
	2	2.43	1.23	0.13	1.53
	4	2.14	2.21	0.10	1.39
	6	1.58	1.13	0.10	0.63
	8	0.99	0.51	ND	0.98
	10	1.40	2.14	ND	1.24
	12	1.25	0.45	ND	1.65
	CD, 5%	0.38	0.67	-	0.378
CAP, B	0	2.34	1.06	0.09	2.34
	2	2.57	2.03	0.58	1.69
	4	2.41	2.26	0.15	1.62
	6	1.49	0.46	0.03	0.67
	8	1.10	0.49	ND	1.08
	10	1.76	1.66	ND	1.33
	12	1.32	0.64	ND	1.73
	CD, 5%	0.53	0.74	-	0.326
CAP, C	0	2.20	1.04	0.07	5.52
	2	2.49	1.42	0.07	2.31
	4	2.59	2.23	0.06	4.08
	6	2.58	3.86	0.06	1.57
	8	1.70	2.86	0.44	2.71
	10	4.05	3.08	ND	3.52
	12	0.93	0.38	ND	10.14
	CD, 5%	1.64	1.32	-	1.536
CAP, D	0	1.15	1.03	0.08	4.42
	2	2.12	1.50	0.04	2.73
	4	2.53	2.06	0.08	3.04
	6	3.11	4.05	0.02	0.18
	8	1.66	1.77	0.19	1.81
	10	2.84	7.34	ND	4.09
	12	0.26	0.29	ND	8.63
	CD, 5%	0.99	2.14	-	1.302

n=3; A, B, C, D - Same as in Table 6.18

**Table 6.20 : Reducing power of CAP during storage at ambient temperature (27-30°C) (n=3)**

Sample	Storage period (Days)	Methanol Extract	Reducing power, A <sub>700</sub> /20 min/100 mg		
			Amino acids fraction	Sugars fraction	Phenols fraction
CAP, A	0	40.52	5.34	42.29	2.42
	2	45.31	7.16	3.04	7.23
	4	36.04	5.42	1.73	0.74
	6	26.17	4.26	3.18	1.26
	8	25.13	2.73	5.47	2.34
	10	15.52	3.49	2.07	1.74
	12	27.05	2.62	2.43	0.79
	CD, 5%	6.22	0.97	1.15	1.12
CAP, B	0	48.47	10.17	26.7	2.87
	2	45.67	6.56	2.23	6.44
	4	37.76	5.53	2.41	0.91
	6	32.93	4.45	2.68	0.66
	8	29.44	3.38	4.83	0.11
	10	18.22	4.25	1.63	2.77
	12	26.63	3.59	2.31	0.40
	CD, 5%	5.59	1.49	1.41	1.04
CAP, C	0	39.26	7.35	22.91	2.59
	2	41.05	5.96	4.11	5.83
	4	35.19	3.82	2.06	1.18
	6	32.93	4.55	2.01	1.44
	8	18.15	3.66	3.81	1.16
	10	7.3	3.4	0.88	3.20
	12	25.67	2.43	1.10	0.59
	CD, 5%	4.84	0.81	3.84	0.63
CAP, D	0	39.71	9.03	26.58	2.30
	2	41.99	5.85	5.29	5.75
	4	36.23	4.48	2.52	1.23
	6	30.71	4.17	2.70	2.08
	8	34.69	4.39	10.55	1.06
	10	4.79	3.85	1.32	4.36
	12	25.23	2.44	2.06	0.26
	CD, 5%	7.86	1.79	1.70	0.79

A, B, C, D - Same as in Table 6.18

As sodium bicarbonate has been shown to eliminate antinutritional factors particularly tannin, attempts were made to extract cashew apple powder at ambient temperature for 1 h with different concentration of sodium bicarbonate ranging from 0.1 to 0.5%. Tannin content and associated antioxidant activity in the methanol extract decreased with increased concentration of sodium bicarbonate

indicating the elimination of tannin is dependent on the concentration of sodium bicarbonate. The loss of antioxidant activity after treatment with sodium bicarbonate indicated the association of antioxidant activity with tannin. The hydrogen peroxide scavenging activity did not decrease after the extraction of cashew apple powder with sodium bicarbonate (Table 6.21).

**Table 6.21 : Effect of extraction of CAP with NaHCO<sub>3</sub> on the anti oxidant activities (n=3)**

Sample	NaHCO <sub>3</sub> concentration, %	Tannin, %	DPPH scavenging activity, $\mu$ moles/15 min/100 mg	Reducing power, A 700/20 min/100 mg	H <sub>2</sub> O <sub>2</sub> scavenging activity, mmols/10 min/100 mg
CAP, A	0	0.18	2.34	36.61	2.76
	0.1	0.11	0.68	11.37	4.79
	0.2	0.07	0.39	10.16	6.63
	0.3	0.05	0.20	9.43	4.22
	0.4	0.07	0.12	10.86	5.95
	0.5	0.04	0.02	13.75	8.66
	CD, 5%	0.025	0.203	4.51	3.47
CAP, B	0	0.20	2.41	43.48	2.86
	0.1	0.11	0.42	13.28	3.99
	0.2	0.08	0.38	12.04	6.21
	0.3	0.09	0.26	15.75	7.97
	0.4	0.12	0.23	14.24	5.98
	0.5	0.04	0.05	12.37	1.41
	CD, 5%	0.038	0.221	3.72	1.91
CAP, C	0	0.27	1.24	42.13	7.24
	0.1	0.13	0.50	17.68	12.44
	0.2	0.08	0.55	17.70	10.97
	0.3	0.07	0.32	14.18	9.53
	0.4	0.08	0.29	13.84	11.73
	0.5	0.07	0.19	14.65	6.21
	CD, 5%	0.042	0.21	3.48	2.86
CAP, D	0	0.24	0.40	43.38	3.4
	0.1	0.09	0.66	15.73	9.17
	0.2	0.10	0.63	13.88	10.96
	0.3	0.09	0.12	12.72	7.57
	0.4	0.09	0.07	10.39	5.76
	0.5	0.08	0.15	15.98	6.29
	CD, 5%	0.038	0.226	1.68	2.78
CAP, E	0	0.64	2.10	44.93	5.52
	0.1	0.27	0.65	11.00	2.36
	0.2	0.19	0.30	6.82	2.21
	0.3	0.11	0.24	4.86	1.66
	0.4	0.10	0.02	6.27	0.46
	0.5	0.11	0.12	14.88	2.05
	CD, 5%	0.062	0.169	2.85	0.83
CAP, F	0	0.76	2.56	48.38	9.63
	0.1	0.35	0.84	13.77	2.25
	0.2	0.19	0.15	9.98	4.72
	0.3	0.14	ND	8.39	4.88
	0.4	0.14	ND	8.24	4.89
	0.5	0.11	0.06	11.74	1.85
	CD, 5%	0.07	0.125	2.29	2.54

A - CAP prepared from red apple by autoclaving and drying; B – CAP prepared from yellow apple by autoclaving and drying; C – CAP prepared from yellow apple after treatment with NaCl and Potassium bisulphite and autoclaving and drying; D – CAP prepared from yellow apple after treatment with NaCl and Potassium bisulphite; E – CAP prepared from solar dried yellow apples; F – CAP prepared from solar dried red apples

Similarly cashew apple has been treated with KMS and sodium bicarbonate and cashew apple powder has been prepared to see the effect on its composition and antioxidant activity. Both DPPH scavenging activity and reducing powder decreased after treatment. Reduction in tannin content is less indicating that sodium bicarbonate is not effective in removing tannins. H<sub>2</sub>O<sub>2</sub> scavenging activity increased due to treatment. Treatment with potassium metabisulphite alone did not have any effect on antioxidant activity and tannin content (Table 6.22).

In an attempt to study the antioxidant activity, cashew nuts and apples have been collected at different maturity stages and these samples have been processed. Results presented in Tables 6.23 to 6.25 indicate that antioxidant activity in both nuts and apples decrease with maturity. Antioxidant activity in methanol extract of cashew shell and cashew kernel oil of released varieties of cashew was determined. Results are presented in Tables 6.26 and 6.27. Significant varietal variation has been noticed.

**Table 6.22 : Antioxidant activity in methanol extract of CAP prepared from cashew apple of variety 'VRI-1' after different treatment (n=3)**

Treatment	Duration of treatment (Days)	Tannin, %	Antioxidant activity in methanol extract of CAP		
			DPPH scavenging activity, $\mu$ mols/ 15 mm/100 mg	Reducing power, A 700/20 min/100 mg	H <sub>2</sub> O <sub>2</sub> scavenging activity, mmols/ 10 min/100 mg
Control	0	0.30	1.88	33.16	4.62
Potassium metabisulphite (0.6g/l)	1	0.33	2.10	36.03	2.83
	3	0.34	2.33	22.26 (32.8)	6.40
	5	0.31	1.89	18.74 (43.5)	6.90
0.5% NaHCO <sub>3</sub> and Potassium metabisulphite (0.6 g/l)	1	0.32	1.82 (3.3)	36.49	6.90
	3	0.31	0.48 (74.6)	28.06 (15.4)	3.33 (27.9)
	5	0.26 (11.8)	0.70 (62.8)	20.84 (37.1)	6.09

Figures within parentheses indicate % reduction compared to control

**Table 6.23 : Antioxidant activity in methanol extract of cashew kernel and shell obtained from nuts at different stages of maturity (n=3)**

Fresh weight, g/nut	DPPH scavenging activity, $\mu$ mols/15 mm/100 mg		Reducing power, A 700/20 min/100 mg		H <sub>2</sub> O <sub>2</sub> scavenging activity, mmols/ 10min/100 mg		Tannin, %	
	Kernel	Shell	Kernel	Shell	Kernel	Shell	Kernel	Shell
0.83	95.29	334.2	894.0	2995.6	80.41	257.9	6.81	0.94
1.05	106.97	410.6	1077.5	2981.5	47.68	ND	6.40	1.13
1.96	71.11	340.0	880.50	1542.8	59.95	131.6	6.64	1.25
3.58	53.35	173.9	684.10	1256.5	64.97	72.15	9.37	1.10
5.21	97.69	267.7	930.90	2127.6	63.08	105.81	8.26	1.21
7.76	0.502	46.6	9.10	352.7	1.42	81.68	0.04	0.53
6.37 (fully mature)	1.77	48.3	14.30	360.6	22.02	107.4	0.15	2.56
Defatted kernel flour	0.86	-	12.89	-	22.93	-	0.17	-
CD (5%)	26.0	108.4	178.70	453.5	32.70	33.6	0.97	0.39
SEd	12.27	50.5	84.30	211.4	15.40	15.7	0.46	0.18

**Table 6.24 : Antioxidant activity in CAP prepared from apple at different stages of maturity (n=3)**

Fresh weight, g/apple	DPPH scavenging activity, $\mu$ mols/15 min/100 mg		Reducing power, $A_{700}/20$ min/100/mg				H <sub>2</sub> O <sub>2</sub> scavenging activity, m mols/10 min/100 mg	
	Methanol extract	Phenols fraction	Methanol extract	A-and fraction	Sugars fraction	Phenols fraction	Methanol extract	Phenols fraction
2.91	4.11	0.68	54.98	2.23	6.31	2.85	3.93	0.765
5.37	2.27	0.71	28.28	1.91	4.35	2.88	3.5	1.07
9.97	2.13	1.62	23.74	2.17	10.74	6.73	1.94	0.87
20.50	2.28	2.30	25.13	1.42	1.27	10.12	1.86	1.54
25.15	2.18	1.57	22.49	3.36	4.31	3.75	2.10	0.29
45.25 (fully	1.69	1.23	22.37	3.85	19.17	5.76	ND	0.17
CD (5%)	0.67	0.609	3.0	0.99	3.0	3.63	-	0.12
SEd	0.31	0.279	1.38	0.45	1.38	1.66	-	0.06

ND – Not detected

**Table 6.25 : Composition of CAP prepared at different maturity stages (n=3)**

Fresh weight, g/apple	Tannin, %	Amino acid, $\mu$ g/100 mg	Phenols, mg $\mu$ g/100	Reducing sugars, %
2.91	0.43	96.74	51.81	2.86
5.37	0.26	76.81	37.94	1.34
9.97	0.26	133.52	14.78	2.93
20.50	0.22	93.29	14.57	2.56
25.15	0.24	108.38	11.96	6.40
45.25 (fully mature)	0.18	127.75	23.13	5.95
CD (5%)	0.051	16.97	4.98	0.52
SEd	0.023	7.79	2.28	0.24

**Table 6.26 : Antioxidant activity of methanolic extract of shell of cashew varieties (n=3)**

Variety	Tannin, mg/g	DPPH scavenging activity, $\mu$ mols/g	Reducing power, $A_{700}/20$ min/g	H <sub>2</sub> O <sub>2</sub> scavenging activity, mols/10 min/g
'NRCC 1'	4.91	302.7	955.3	0.93
'NRCC Sel.2'	10.24	259.2	565.6	0.51
'Bhaskara'	4.29	318.2	677.8	0.52
'VRI-1'	11.68	301.9	1217.6	0.38
'VRI-2'	7.08	290.3	1799.5	0.60
'VRI-3'	9.17	269.9	813.5	0.85
'V1'	13.38	374.3	2427.0	1.29
'V2'	7.41	307.9	1095.5	0.17
'V3'	2.31	188.6	805.1	0.49
'V4'	7.73	176.8	1470.8	0.20
'V5'	4.64	140.6	1338.6	0.42
'V6'	3.99	280.7	2082	0.88
'V7'	2.33	157.6	1138	0.65
'Ullal -1'	4.96	192.0	462.8	0.62
'Ullal -2'	7.00	211.1	1075.7	0.72
'Ullal-3'	4.49	198.3	1483.0	1.43
'Ullal-4'	2.53	241.9	715.1	0.13
'UN 50'	4.38	381.1	1189.0	0.68
'BPP-1'	4.44	230.4	1495.9	0.34
'BPP-2'	9.17	253.8	2518.3	0.70
'BPP-5'	6.84	237.6	1538.7	0.15
'BPP-6'	5.09	160.4	1511.7	0.32
'Bhubaneswar-1'	6.24	425.4	312.5	1.07
'Chintamani-1'	10.38	181.3	1709	0.36
'Jhargram-1'	28.23	133.9	1783.8	1.46
'Akshaya'	5.06	128.4	1203.2	0.6
'Anagha'	5.08	384.7	2061.5	0.64
'Sulabha'	7.17	287.7	1108.7	0.84
'Priyanka'	7.03	315.5	2001.6	0.28
'Dharasri'	3.63	142.0	575.7	0.40
'Amrutha'	6.37	172.0	1553	0.57
'Kanaka'	8.86	179.9	1181.7	1.33
'Dhana'	6.76	166.9	1443.9	0.70
'BLA 39-4'	17.82	439.2	1994.1	0.69
CD (5%)	0.483	52.5	278.0	0.21

**Table 6.27 : Antioxidant activity of cashew kernel oil (n=3)**

Variety	DPPH scavenging activity, $\mu\text{moles}/15\text{ min/g oil}$
'Sel.1'	0.44
'Sel.2'	0.91
'Bhaskara'	0.51
'Ullal - 1'	0.71
'Ullal -2'	0.40
'Ullal -3'	0.54
'Ullal -4'	0.58
'UN 50'	0.51
'V1'	0.62
'V2'	0.67
'V3'	0.60
'V4'	0.40
'V5'	0.69
'V6'	0.58
'V7'	0.61
'VRI-1'	0.59
'VRI -2'	0.24
'VRI-3'	0.73
'BPP-1'	0.43
'BPP-2'	0.42
'BPP-5'	0.23
'BPP-6'	0.63
'Jhargram-1'	0.64
'Chintamani-1'	0.89
'Bhubaneswar-1'	0.80
'Amrutha'	0.73
'Akshaya'	0.36
'Anagha'	0.78
'Kanaka'	0.40
'Dhana'	0.42
'Dharasri'	0.57
'Priyanka'	0.37
'Sulabha'	0.84
'NDR 2-1'	0.64
'BLA 39-4'	0.50
CD (5%)	0.197

Antioxidant activity in the cashew apple juice after different treatment was determined (Table 6.28). Dialysis for 24 h and boiling for 15 min resulted in total loss of activity indicating that the antioxidant activity in cashew apple is associated with low molecular weight compounds.

Antioxidant activity of cashew apple powder and cashew apple pomace of red and yellow coloured apple was determined (Table 6.29). DPPH activity did not differ between cashew apple powder and cashew apple pomace. Reducing power, however, was less in cashew apple pomace compared to cashew apple powder which is mainly due to squeezing of juice before preparing cashew apple pomace.

#### 6.3.4 Conclusions

Solar dried cashew apple powder of released varieties have been analysed for crude fibre and ascorbic acid contents . Further, in vitro digestibility of crude fibre extracted from cashew apple powder by diastase have been studied. Varieties with higher crude fibre (Chintamani-1, 4.7%) and ascorbic acid content (UN 50, 170  $\mu\text{g}/100\text{ mg}$ ) have been identified. Studies with in vitro digestibility of crude fibre revealed hat crude fibre from Ullal-2 could be digested better compared to other varieties. Significant variation among different varieties for crude fibre, ascorbic acid contents and in vitro digestibility of crude fibre by diastase has been noticed.

Salt treatment in presence of KMS for 5 days followed by autoclaving for 10 min at 16 psi and drying at 70°C for 2 days helps in preparing cashew apple powder with lower tannin content. Antioxidant activities has been shown to be associated with tannin, phenols, sugars and amino acids. Cashew apple powder could be blended upto 20% with cereal flour for enhancing antioxidant properties which is dependent on concentration of cashew apple powder.

Antioxidant activity in cashew apple juice is associated with low molecular compounds. Treatment of cashew apple with  $\text{NaHCO}_3$  at 0.5% concentration for 5 days resulted in reduced antioxidant activity. Its

activity in cashew apple powder and cashew apple pomace did not differ. Its activity decreased during maturity of cashew nuts and apples. The antioxidant activity in cashew apple powder is stable for four months of storage at ambient temperature (27-30°C). The antioxidant activity in cashew shell and kernel oil, varied among varieties analysed.

### 6.3.5 Publications

- i) Nagaraja, K.V., Shobha, D., Yogeesh. 2007. Extraction of tannin from cashew kernel testa at acidic pH. *J Food Sci. Technol.* 44:636-638.
- ii) Nagaraja, K.V., Shobha, D., Yogeesh. 2008. Preparation and biochemical analysis of cashew apple powder. *J. Food Sci. Technol.* 45:228-236.

**Table 6.28 :** Antioxidant activity in cashew apple juice (n=3)

Antioxidant activity	Treatment	Red coloured apple		Yellow coloured apple	
		Control	Clarified***	Control	Clarified***
DPPH scavenging activity, $\mu$ moles/15 min/100 $\mu$ l juice	Control	906	9951222	1207	
	Boiled*	1308	1292	1747	1566
	Dialysed**	32.2 (96)	10.8 (99)	2.9(100)	3.55(100)
Reducing power, A 700/20 min/100 $\mu$ l juice	Control	4.05	2.87	5.20	4.55
	Boiled	4.52	5.12	8.21	6.80
	Dialysed	0.26 (94)	0.27 (90)	0.07(99)	0.06(100)
Tannin, $\mu$ g/100 $\mu$ l	Control	44.3	39.87	43.04	21.94
	Boiled	41.72 (5.8)	37.15 (6.8)	95.52	68.42
	Dialysed	8.17 (82)	5.48 (86)	4.25(90)	7.79 (64)

\* - Cashew apple juice (10 ml) was boiled for 15 min. centrifuged and used for assay; \*\* - Cashew apple juice was dialysed at 4°C for overnight against distilled water, centrifuged and used; \*\*\* - Cashew apple juice (10 ml) was treated with 5 mg of gelatin for 12 h at 4°C, centrifuged, and supernatant used for assay; Figures within parentheses indicate % reduction compared to the respective controls.

**Table 6.29 :** Antioxidant activity in CAP and pomace (n=3)

Antioxidant activity	Red coloured apple		Yellow coloured apple	
	Apple powder	Apple pomace	Apple powder	Apple pomace
DPPH scavenging activity, $\mu$ mols/15 min/100 mg	1.91	1.53	2.5	2.17
Reducing power, A 700/20 min/100 mg	25.53	5.38	26.45	4.76
H <sub>2</sub> O <sub>2</sub> scavenging activity, $\mu$ mols/10 min/100 mg	12.26	12.04	9.38	7.67
Tannin, $\mu$ g/100 mg	0.36	0.314	0.19	0.27
Phenols, $\mu$ g/100 mg	31.11	22.77	28.84	30.17
Reducing sugars, %	34.36	3.26	35.5	5.45
Amino acid, %	0.95	1.481	0.66	0.77



**EDUCATION  
TRAINING  
GENERAL  
MISCELLANEOUS  
INFORMATION**

## 7. EDUCATION AND TRAINING

- Training on “Soft wood grafting techniques in cashew ” (21-22, August, 2007) for officials from Development Departments of Goa and Gujarat.
- Three days refresher course on “Pruning in Cashew and Composting of Cashew Biomass” (18-20, December, 2007) for officials of Development Departments from Goa and Assam on Canopy Management in Cashew and Composting of Cashew Biomass through Japanese and vermicomposting methods.
- A refresher course on “Cashew Production Technology” (22-24, January, 2008) for the officials of Development Departments from Goa and Assam.
- Training programmes (three) on “Cashew apple utilization ” was organized for farm women in collaboration with Nagarika Seva Trust, Guruvayanakere. The participants (around 100) were imparted training on preparation various cashew apple products.
- Ten one day training programme on "Cashew Production Technology" (Jan – Feb 2008) for the farmers sponsored by KVK of CPCRI, Kasaragod. In this programme about 300 farmers were trained on various aspects of Cashew Production Technology.
- A special course on “Cashew Production Technology” (3-5, March 2008) for the officials of Bodoland Development Council, Assam , BAIF Development and Research Foundation, Pune and Department of Forests, Goa. A total of 28 officials were imparted training on improved cashew cultivation practices

## 8. LINKAGES / COLLABORATION

Name of the organization	Type of collaboration
Central Food Technological Research Institute, Mysore	DBT Funded Project on Nutraceuticals
SKDRDP, Dharmasthala Manaje Vyavasaya Sahakari Seva Society, Kamashile	Maintenance of demonstration plots, trainings, distribution of planting materials and Annual Cashew Day
Directorate of Cocoa and Cashew Development, Kochi	Farmers training programme
Cashew Export Promotion Council of India, Kollam.	Insecticide residue analysis
Department of Horticulture, Karnataka Karnataka Cashew Manufacturer’s Association, Mangalore. Agricultural Research Station, Ullal, Mangalore.	Farmers training programmes

## 9. AICRP-CASHEW CENTRES

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## 10. PUBLICATIONS

### 10.1 Research Publication

Balasubramanian, D. 2007 Optimization of Cashewnut processing. *Cashew News* **12** (2):2 .

Balasubramanian, D. 2008. Farm level Cashewnut processing. *Cashew Bulletin* **XLV** (10) : 3-4.

Balasubramanian, D. 2008. Role of women in Cashew processing and opportunities for entrepreneurship. Contributory paper for the compendium on “Women specific production and post production technologies in Horticulture crops”, National Research Centre for Women, Bhubaneshwar, Orissa.

Bhat, P.S. and Raviprasad, T.N. 2008. Studies on lindane and chlorpyrifos residues in cashew kernels. *J. of Plantation Crops* **36** (2).

Nagaraja , K.V. Bhuvaneshwary S. and Swamy , K.R.M. 2007. Biochemical characterization of juice and pomace of germplasm accessions and released varieties of cashew ( *Anacardium occidentale* L) in India . *Plant Genetic Resources Newsletter* **149**:9-13.

Nagaraja ,K.V. 2007. Biochemistry of cashew (*Anacardium occidentale* L) : A review . *J.Food Sci.Technol.* **44**:1-9.

Nagaraja ,K.V. 2007. Extraction of tannin from cashew kernel testa at acidic pH . *J.Food Sci.Technol.* **44**:636-638.

### 10.2 Papers presented in Symposia / Workshop / Seminar

Balasubramanian, D. 2008. Present status and future prospects of Mechanisation in Cashew Processing. **In:** Interactive meeting on “Tools and machinery for the development of horticultural crops” at Central Institute of Sub tropical horticulture, Lucknow, Uttar Pradesh on 18<sup>th</sup> January, 2008.

Balasubramanian, D. 2008. Processing of Cashewnut and apple.**In:** State level Cashew seminar on “Processing of Horticultural Crops” conducted by Department of Horticulture, Mangalore at Puttur on 22<sup>nd</sup> February, 2008.

Balasubramanian, D. 2008. Advanced Production Technologies and value Addition in Cashew. **In:** State level Cashew seminar on “Advanced Production Technologies and Value

addition in Cashew” organized by Regional Research Station, Vridhachalam, Tamilnadu on 4<sup>th</sup> March, 2008.

Balasubramanian, D. 2008. Farm level cashewnut processing – Potential and Opportunities. **In:** State level Cashew Workshop at Regional Agricultural Research Station, Pillicode on 15<sup>th</sup> March, 2008.

Balasubramanian, D. 2008. Pilot Demonstration for Popularization on Utilization of Cashew apple. **In:** State level Cashew seminar conducted by Kadamba Marketing Souharda Sahakari Ltd., Sirsi, Karnataka on 26<sup>th</sup> March, 2008.

Bhat,M.G. 2007. Achievements, Constraints, Opportunities for Cashew Development in India with Special Reference to North Eastern Hilly (NEH) Region. Presented in 2<sup>nd</sup> Indian Horticulture Congress 2007. **In :** Souvenir and Abstracts (Ed. By Dr. K.. Chadha *et al* ) P 24, ICAR Research Complex for NEH Region, Barapani, Meghalaya ,18-21 April 2007.

Bhat,M.G. 2007. “Cashew Research in Emerging Development Scenario” . Presented in the 6<sup>th</sup> National Seminar “Indian Cashew in the Next Decade – Challenges and Opportunities at Raipur. **In :** Souvenir. (Ed. Mr. Venkatesh N. Hubballi), pp 14-24 ,18-19 May 2007.

Bhat,M.G. Yadukumar. N. and Nayak, M.G. 2007. Cashew Technologies Developed. **In :** Souvenir of Horticulture Summit 2007 (Ed. R. Kishun *et al.*). pp 108-111, Confederation of Indian Horticulture, Central Institute of Subtropical Horticulture : 16-19 June 2007, Lucknow.

Bhat ,M.G. 2007. “Cashew cultivation and production to use marginal waste land”. **In :** Horticulture Summit – 2007, June 16-19, 2007, Lucknow. Confederation of Indian Horticulture.

Bhat,M.G., Yadukumar,N. and Nayak,M.G. 2007. Cashew Research Achievements, Technologies Developed and Research and Development Strategies. **In :** Souvenir and Extended Summaries (Ed : A.R. Desai *et al*) pp 3-15. Lead Paper presented in National Seminar on Research, Development and Marketing of Cashew. Technical Session I : Crop Improvement ICAR Research Complex for Goa, Ela, Old Goa, 20-21 November 2007.

Bhat, M.G., 2007. Cashew Research Achievements and Development Strategies. **In** : Souvenir – Silver Jubilee Celebrations (1982 – 2007) of Zonal Agricultural Research Station (UAS), Brahmavar (Ed. Dr. T.R. Guruprasad *et al* ZARS, Brahmavar) pp 37-44.

Bhat P.S., and Raviprasad T.N. 2007. Management of tea mosquito bug *Helopeltis antonii* Sig. with newer insecticide/products. **In**: National seminar on Research, Development, and Marketing of Cashew. ICAR Research Complex for Goa during 20- 21 November, 2007. pp 80-81.

Nayak, M.G. 2007. Effect of pruning on cashew. **In** : National seminar on Research, Development and Marketing of Cashew. ICAR Research Complex for Goa during 20-21 November, 2007.

Nagaraja, K.V. and Balasubramanian, D. 2007. Processing and value addition in cashew (Lead paper). **In**: National seminar on Research, Development, and Marketing of Cashew. ICAR Research Complex for Goa during 20- 21 November, 2007.

Raviprasad, T.N. and Bhat, P.S. 2007. Standardization of egg collection technique and laboratory rearing of young grubs of cashew stem and root borers (CSRB). **In**: National seminar on Research, Development, and Marketing of Cashew. ICAR Research Complex for Goa during 20- 21 November, 2007. pp 76-77.

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. **In**: National seminar on Research, Development, and Marketing of Cashew. ICAR Research Complex for Goa during 20- 21 November, 2007. pp 63-64.

Yadukumar, N., Rejani R. and Nandan, S.L. 2007. Green manuring for high density cashew orchards **In**: National seminar on Research, Development, and Marketing of Cashew. ICAR Research Complex for Goa during 20- 21 November, 2007. pp 59-61.

### 10.3 Technical Reports / Bulletins / Compendia

Balasubramanian, D. 2008. Indiavil Mundirikotaikalai Padhanpaduthuthal (Cashewnut processing industries in India). **In**: Mundiriyil Mempaduthappatta Melanmai Thozhilil Nutpangal (Advanced production technologies and Value addition in Cashew) Eds., Aneesa rani, M.S., Jeeva S., Ambedkar V and P Viswanathan. Regional Research Station, Tamilnadu Agricultural University, Vridhachalam, Cuddalore, Tamilnadu.

National Research Centre for Cashew. 2007. Annual Report 2006-07, Puttur, Karnataka, 82 pp.

National Research Centre for Cashew. 2007. Cashew News, Newsletter. Vol. 12 (1), Jan-Jun 2007, Puttur, Karnataka. 8 pp.

National Research Centre for Cashew. 2007. Cashew News, Newsletter. Vol.12 (2), July – Dec. 2007, Puttur, Karnataka, 8 pp.

National Research Centre for Cashew 2007 Research Highlights 2006-2007, 24pp.

Nagaraja K.V. and Bhat P.S. 2007 Vision 2025 National Research Centre for Cashew, Puttur, Karnataka 46 pp.

### 10.4 Extension bulletins / pamphlets

Nayak M.G., Bhat P.S. and Raviprasad T.N. 2007 Top working in cashew (Kannada): National Research Centre for Cashew Extension Handout No.10 (Revised), 6pp.

Yadukumar N., Nayak M.G. and Bhat P.S. 2008 Cashew Cultivation Practices (Kannada): National Research Centre for Cashew Extension Handout No.1 (Revised), 6pp.

### 10.5 Technical bulletin

Balasubramanian, D., 2007 Process catalogue on development of an economically viable on-farm cashew nut processing. (Ed : P .S. Bhat) NRCC Technical Bulletin No.10. 14pp

Nagaraja, K.V. 2008. Nutritive value of cashew. National Research Centre for Cashew, Puttur (Revised), 12 pp.

### 10.6 Bibliography

Annotated Bibliography on Cashew (1995-2007) 2008 National Research Centre for Cashew. 2007, Karnataka, 216 pp.

## 11. LIST OF ONGOING RESEARCH PROJECTS

Project No.	Title
<b>I CROP IMPROVEMENT</b>	
1.1	Collection, conservation, cataloguing and evaluation of cashew germplasm (M.G. Nayak, M.G. Bhat and P.S. Bhat).
1.2	Varietal Improvement of Cashew (J.D.Adiga, M. G. Nayak and M.G. Bhat).
Ad-hoc	Molecular characterization of cashew using RAPD and isozyme markers (Thimmappaiah).
DBT	Identification of molecular markers linked to economic characters (Thimmappaiah).
<b>II CROP MANAGEMENT</b>	
2.2(b)	Fertilizer application and pruning trials in high density 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).
2.13	Green manuring in cashew to increase productivity of cashew (N. Yadukumar and R. Rejani).
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).
<b>III CROP PROTECTION</b>	
3.7	Studies on pheromones of tea mosquito bug <i>Helopeltis antonii</i> S.(P.S. Bhat and T.N. Raviprasad).
3.9	Bioecology and management of lepidopteran flower and fruit pests of cashew (D. Sundararaju).
3.10	Foraging behaviour of pollinators of cashew (D.Sundararaju).
3.11	Investigations on insect fauna associate with Cashewnut /kernels(TN Raviprasad and P.S. Bhat).
3.12	Role of pollinators in improving productivity of cashew (D.Sundararaju).
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).
Paid up Trial	Evaluation of newer insecticides against tea mosquito bug <i>Helopeltis antonii</i> S. (P.S.Bhat).
<b>IV POST HARVEST TECHNOLOGY</b>	
4.7	Developing economically viable on- farm cashew nut processing (D. Balasubramanian).
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 utilization of cashew nut shell cake (D. Balasubramanian).
4.13	Design development and evaluation of solar tunnel dryer for cashew apple (D. Balasubramanian).
DBT	Nutraceuticals for healthy and speciality foods through biotechnology approaches (K. V. Nagaraja).
<b>V TRANSFER OF TECHNOLOGY</b>	
5.1	Transfer of technology programme in cashew (M.G. Nayak, P.S. Bhat and N. Yadukumar).

## 12. IMPORTANT MEETINGS AND SIGNIFICANT DECISIONS

### 12.1 Research Advisory Committee

Dr. M.K.Nair, Chairman, RAC, NRCC, Shreeraj, Bedradka Post Via Kudlu, Kasaragod – 671 124, Kerala	Chairman
Prof. D.P. Ray, Dean, Orissa University of Agriculture and Technology Bhubaneswar – 751 003, Orissa	Member
Dr. M.S. Kuruvinashetti, Head, Department of Biotechnology, College of Agriculture University of Agricultural Sciences, Dharwad – 580 005	Member
Dr. G. Gajendran, Professor of Entomology, Anbil Dharmalingam Agricultural College and Research Institute, Navalur Kuttapattu, Tiruchy - 620 009, Tamil Nadu	Member
Dr. A.G. Appu Rao, Head, Protein Technology Division Central Food Technological Research Institute, Mysore – 570 020	Member
Dr. K.V. Ramana, Asst. Director General (Hort-II), Indian Council of Agricultural Research, Krishi Anusandhan Bhavan-II, Pusa Gate, New Delhi – 110 012	Member
Mr. G.K. Naidu, No.4, 2nd Cross Street, Jeth Nagar, R.A. Puram Chennai – 600 028	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, NRC-Cashew, Puttur, Karnataka-574 202	Member
Dr. N.Yadukumar, Principal Scientist (Agronomy) NRC-Cashew, Puttur, Karnataka – 574 202	Member-Secretary

Composition of 4<sup>th</sup> RAC (from 7-10-2005 to 6-10-2008)

(Constituted vide ICAR Officer Order No. 13(8)/1995-IA-V dated 27-10-2005 of Under Secretary [Hort])

The third meeting of the fourth RAC (12<sup>th</sup> meeting) of the Centre was held during 5-6 May 2008 under the Chairmanship of Dr. M.K.Nair, Former Director CPCRI, Kasaragod. Drs. D.P. Ray, G. Gajendran, A.G. Appu Rao and M.S. Kuruvinashetti participated in the meeting. The progress made under the research projects was discussed in the meeting.

## 12.2. Institute Management Committee

Name and Address	Status
Dr. MG Bhat, Director, NRCC, Puttur, - 574202, DK District, Karnataka.	Chairman
Assistant Director General (Hort-II), ICAR, Krishi Anusandhan Bhavan-II, New Delhi-110 012	Member
The Joint Director of Horticulture, (Plantation Crops & Plant Protection), Lalbagh, Bangalore-560 004, Karnataka	Member
Dr. S. Rajan, Associate Director of Research, Kerala Agricultural University, Vellanikara, Thrissur, Kerala -680 656. (Representing Dept. of Agriculture, Govt. of Kerala)	Member
Dr. J. Venkatesha, Director of Instruction (Hort), Horticulture College, Mudigere -577 132, Chickmagalore, District. Karnataka	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	Member
Dr. K.V.Nagaraja, Principal Scientist (Biochemistry), NRCC, Puttur - 574202, DK District, Karnataka.	Member
Dr. Thimmappiah, Principal Scientist (Genetics & Cytogenetics), NRCC, Puttur - 574202, DK District, Karnataka.	Member
Dr. (Mrs.) R. Rejani Scientist (Soil & Water conservation Engineering), NRCC, Puttur- 574202, DK District, Karnataka.	Member

The Institute Management Committee met twice on (22.12.2007 and 31.01.2008) 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 were finalized during the meetings. IMC's tenure is for three years from 28.11.06.

## 12.3 Institute Research Committee (IRC) Meeting

The twentieth Institute Research Committee (IRC) meeting was held on 22<sup>nd</sup> and 23<sup>rd</sup> June 2007. In the introductory remarks, Dr. M.G. Bhat, Director, NRC Cashew 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. Phundan Singh Ex- Director and Principal Scientist, CICR, Nagpur; “Crop Management” chaired by Dr. J. Venkatesh, Director of Instructions (Horticulture), College of Horticulture, Mudigere; “Crop Protection” chaired by Dr. Abraham Varghese, Principal Scientist (Agricultural Entomology), IIHR, Bangalore; “Post Harvest Technology” chaired by Dr. V. Chikkasubbanna, Professor and Head, Division of Horticulture, GKVK, UAS, Bangalore and “Transfer of Technology” chaired by Dr. M.R. Hegde, Principal Scientist and Head, IIHR, Bangalore. The scientists of the centre presented progress made under various projects.

## 12.4 Quinquennial Review Team (QRT) Meeting

The QRT consisting of Dr. S.S. Magar former Vice Chancellor of Dr. Balasaheb Sawant Kokan Krishi Vidyapeeth, Dapoli (Chairman); and Dr. P.L. Tandon, Dr. C.K. Nair, Dr. C.T. Devadas Dr. P.C. Lenka and Dr. L.V. Kulwal (Members) visited NRC Cashew during 29-30 May 2007 to review research activities of the Centre for the period 2002 to-2006. Dr. M.G. Bhat, Director explained about the research activities of NRCC and salient achievements. This was followed by the presentations of research projects by the project leaders. The QRT also visited the experimental plots both at Kemminje and Shantigodu and offered the comments. The team met again during 26-29 December 2007 and finalized the report to be submitted to ICAR, New Delhi based on its review of the research activities of NRCC and all the Centres under AICRP on cashew for the period from 2002 to-2006. The QRT report as per the ICAR norms was presented to IMC for their views and the report was sent to council on 28<sup>th</sup> February 2008.

## 12.5 Institute Joint Staff Council (IJSC)

	VI IJC (Upto 28-2-08)	VII IJC (From 1-3-08)
<b>Official Side</b>		
Dr. M.G. Bhat	Chairman	Chairman
Dr. K.V. Nagaraja	Member	-
Dr.D. Sundararaju	-	Member
Dr. P.S. Bhat	Member	-
Dr. J.D.Adiga	-	Member
Shri. K. Sanjeeva	Member	Member
Shri. H. Ganesha	Member	Member
Dr. D.Balasubramanian	Member-Secretary	-
Dr.(Mrs) R.Rejani	-	Member- Secretary
<b>Staff Side</b>		
Shri. R.Muthuraju	-	Member-Secretary
Shri. K.V. Ramesh Babu	Member (CJSC)	Member (CJSC)
Shri. Lakshmipathi	Member-Secretary	-
Shri. K.M. Lingaraja	Member	Member
Shri. K. Balappa Gowda	Member	Member
Shri. S. Ammu Gowda	Member	-
Shri. K. Narayana	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

## 12.6 RAJBASHA

राजभाषा कार्यान्वयन एवं प्रगती

### राजभाषा कार्यान्वयन समिति

- |     |                         |            |
|-----|-------------------------|------------|
| 1.  | डॉ. एम. जी. भट्ट        | अध्यक्ष    |
| 2.  | डॉ. टी. एन. रविप्रसाद   | सदस्य      |
| 3.  | श्री लक्ष्मीपती         | सदस्य      |
| 4.  | श्री प्रकाश जी. भट्ट    | सदस्य      |
| 5.  | श्री के. एम. जयराम नायक | सदस्य      |
| 6.  | श्री के. सीताराम        | सदस्य      |
| 7.  | श्री उमाशंकर            | सदस्य      |
| 8.  | कुमारी विन्नी लोवो      | सदस्य      |
| 9.  | श्री रविशंकर प्रसाद     | सदस्य      |
| 10. | श्री के. संजीव          | सदस्य सचिव |

वर्ष 2007-08 में, केन्द्र में राजभाषा कार्यान्वयन समिति की चार बैठक आयोजित किया गया। बैठकों में हिन्दी कार्यान्वयन की प्रगति के बारे में चर्चा किया गया। वार्षिक कार्यक्रम के अनुसार जरूरी लक्ष्यों को प्राप्त करने के लिए आवश्यक कदम उठाने के बारे में चर्चा किया गया और अनेक जरूरी निर्णय भी लिए गए।

हिन्दी में कार्यालयीन कार्य करनेवालों को प्रोत्साह देने की दृष्टि से अनेक प्रोत्साहन योजनाओं को जारी किया गया है। केन्द्र के बहुसंख्यक कर्मचारी हिन्दी में कार्यसाधक ज्ञान प्राप्त कर चुके हैं। हिन्दी में प्राशिक्षण दिलाने के लिए प्रबोध, प्रवीण, प्राज्ञा परीक्षा से संबंधित सी.डी.यों को उपलब्ध कराया गया है।

कार्यालय में सभी नामफलक, प्रपत्र, मोहरे आदियों को द्विभाषी बनाया गया है। कर्मचारियों को हिन्दी में काम करने की जिज्ञाक दूर करने के लिए समय समय पर हिन्दी कार्यशाला, सितंबर माह में हिन्दी पखवाडा आदी कार्यक्रम आयोजन किया जा रहा है।

#### पुत्तूर नगर राजभाषा कार्यान्वयन समिति (नराकास)

राष्ट्रीय काजू अनुसंधान केन्द्र पुत्तूर नगर राजभाषा कार्यान्वयन समिति (नराकास) के संयोजक है। यह केन्द्र, आसपास के सभी केन्द्र सरकारी कार्यालयों में राजभाषा हिन्दी की प्रगामी प्रयोग के लिए जरूरी विभिन्न कार्यक्रमों को आयोजित करती है।

हमेशा की तरह इस वर्ष भी नराकास के दो अर्धवार्षिक बैठक आयोजित हुआ था। इन बैठकों में क्षेत्रीय कार्यान्वयन कार्यालय बेंगलूर से आए अधिकारियों ने सदस्यों को मार्गदर्शन किए। हर कार्यालय में हिन्दी की प्रयोग को बढ़ावा देने के लिए जरूरी कदम उठाने के बारे में चर्चा किया गया और निर्णय भी लिया गया। जुलाई महिने में सदस्य कार्यालयों के कर्मचारियों की सुविधा के लिए एक दिन का हिन्दी कार्यशाला आयोजन किया गया था। दक्षिण भारत हिन्दी प्रचार सभा, पुत्तूर शाखा के अध्यापक परमेश्वर भट्ट जी ने मार्गदर्शन किया। इस वर्ष भारत संचार निगम, पुत्तूर शाखा ने उनके कर्मचारियों की सुविधा के लिए एक दिन की हिन्दी कार्यशाला आयोजन किया था।

सितंबर 14-28 तक बहुत ही उत्साहपूर्ण वातावरण में सभी सदस्य कार्यालयों की सहयोग से हिन्दी पखवाडा मनाया गया। पखवाडा का उद्घाटन समारोह काजू अनुसंधान केन्द्र, पुत्तूर में हुआ था और समारोप समारोह सी पी सी आर आई, विट्टल में हुआ। पखवाडा के मौके पर कर्मचारियों के लिए अनेक प्रतियोगिताओं को आयोजन किया गया था। हिन्दी कार्यान्वयन को विस्तृत रूप देने की दृष्टि से नगर के शाला विद्यार्थियों को, हिन्दी अध्यापकों को, पोषकों को कार्यक्रमों में शामिल किया गया था। हिन्दी परीक्षाओं में उन्नत अंक प्राप्त किए विद्यार्थियों को नकद पुरस्कार से सम्मानित किया गया।

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

M.G.Bhat	Second Indian Horticulture Congress-2007 held at ICAR Research Complex for NEH Region, Barapani, Meghalaya.	18-21 April 2007
M.G.Nayak	Review of Horticultural Research Projects on Cashew at ICAR Research Complex at Goa.	19 - 20 April 2007
M.G.Bhat	National Horticultural Research Conference-2007 of Directors of Institutes / NRCs and Project Coordinators under Horticulture Division at ICAR Lecture Hall, NAAS Building, NASC Complex, Pusa, New Delhi.	27-28 April 2007
M.G.Nayak	Workshop on "Share your experience in seed production, marketing and intellectual property rights management" at Sugarcane Breeding Institute, Coimbatore.	29 April 2007
M.G.Bhat N.Yadukumar D.Sundararaju T.N.Raviprasad	Participated in the 6 <sup>th</sup> National Seminar on Cashew – Indian Cashew in the Next Decade – Challenges and Opportunities. Organized by Department of Horticulture (Govt. of Chhattisgarh) and DCCD, Kochi at, Raipur.	18-19 May 2007
M.G.Bhat	Horticulture Summit – 2007 (Stakeholders' Meet for Accelerated Development of Horticulture) organized by Confederation of Indian Horticulture and Central Institute for Subtropical Horticulture at Lucknow.	16-19 June 2007
M.G.Nayak	Review meeting of ICAR Mega Seed Project, Seed Production in Agricultural Crops and Fisheries at CISH, Lucknow.	29-30 June 2007
M.G.Bhat	Expert Consultation on "Science and shaping of the future of Plantation Crops" and meeting of Chairs of all Commodity Boards under the Department of Commerce and Research Groups including those from Academic and Private Sector convened by Shri Jairam Ramesh, Hon'ble Minister of State for Commerce, Govt. of India.	30 June 2007

M.G.Bhat	Meeting of Project Coordinators of Horticulture Division of ICAR under the Chairmanship of Deputy Director (Hort) ICAR for discussion on the XI Plan proposals pertaining to AICRPs.	3 - 4 July 2007
M.G.Nayak	Food Expo – 2007 at NASC Complex, Pusa held on the occasion of ICAR Foundation Day.	16 - 17 July 2007
M.G.Bhat	ICAR Directors' Conference at NASC Symposium Hall, NASC Complex, Pusa, New Delhi.	16-18 July 2007
M.G.Bhat	Regional Workshop / Meeting on Planting Material and Rejuvenation of Horticulture Crops held under the Chairmanship of Sri SM Desalphine, Additional Secretary, Department of Agriculture at Department of Horticulture, Lalbagh, Bangalore.	21 September 2007
M.G.Bhat	Silver Jubilee Celebrations (1982 – 2007) of Zonal Agricultural Research Station (UAS), Brahmavar and chaired Technical Session on Cashew Cultivation and Plantation Crops at ZARS, Brahmavar.	24 October 2007
M.G.Bhat	Participated in the Special Interactive Workshop on Administrative and Financial Matters for the Directors, Administrative and Financial Heads of the ICAR Institutes under Southern one at NIANP, Bangalore.	26 – 27 October 2007
M.G.Bhat	Participated in the Foundation Day Celebrations of ASRB, Pusa, New Delhi at NASC Complex, Symposium Hall, Pusa, New Delhi.	5 November 2007
M.G.Bhat K.V.Nagaraja N.Yadukumar M.G.Nayak P.S.Bhat	National seminar on Research, Development, and Marketing of Cashew at ICAR Research Complex for Goa.	20-21 November 2007
T.N.Raviprasad M.V.Nagaraja N.Yadukumar M.G.Nayak P.S.Bhat T.N.Raviprasad	National Group Meeting of Scientists of AICRP on Cashew at ICAR Research Complex for Goa.	22-24 November 2007
J.D.Adiga M.G.Bhat	Brainstorming Session on 'Horticulture for Livelihood and Nutritional Security in A & N Islands' to prepare long term Horticultural Policy and Action Plan at CARI, Port Blair.	2 - 3 December 2007
M.G.Bhat	Meeting of Directors/Project Coordinators of Horticulture Division under the Chairmanship of DDG (Hort) to discuss about EFC at IIHR, Bangalore.	17 – 18 December 2007
M.V.Nagaraja	Interaction Meeting of Members of Karnataka Cashew Manufacturers Association (KCMA) with QRT in Mangalore.	27 December 2007
M.G.Bhat	XXI Meeting of ICAR Regional Committee No. VIII at Central Tuber Crops Research Institute, Thiruvananthapuram.	11 - 12 January 2008
M.G.Nayak M.K.Narayanan	Interactive Meeting on tools and machinery for the Development of Horticulture at CISH, Lucknow, Uttar Pradesh.	18 January 2008

M.G.Bhat	Interface programme on Statistical Methods for Social Sciences Research, CPCRI, Kasaragod.	31 January 2008
T.N.Raviprasad	Theme based seminar on “Technologies for Organic Production of Cashew”.	12 February 2008
D.Balasubramanian	State level Cashew seminar on “Processing of Horticultural Crops” conducted by Department of Horticulture, Mangalore at Puttur.	22 February 2008
D.Balasubramanian	State level cashew seminar on “Advanced Production Technologies and Value addition in Cashew” organized by Regional Research Station, Vridhachalam, Tamilnadu.	4 March 2008
M.G.Bhat	Interactive Meeting for finalization of “Handbook of Seed and planting Material Testing Manuals and Labels for Horticultural Crops”	11-12 March 2008
D.Balasubramanian	State level Cashew Workshop at Regional Agricultural Research Station, Pillicode and participated in the group discussion on utilization of cashew apple.	15 March 2008
K.V.Nagaraja D.Balasubramanian	One day training program on “Pilot Demonstration for Popularization on Utilization of Cashew apple” conducted by Kadamba Marketing Souharda Sahakari Ltd., Sirsi, at Kumta, Karnataka.	26 March 2008

#### **14. FARMER’S DAY/KRISHIMELA/EXHIBITION/ CAMPAIGNS/CONSULTANCY**

N.Yadukumar D.Sundararaju P.S.Bhat J.D.Adiga	Visit to cashew garden of the members of Khanapur Cashew Growers Association, Bhatwada, Khanapur taluk, Belgaum for consultancy.	30-31 August 2007 and 19-20 February 2008
M.G.Nayak P.S.Bhat	Visit to cashew plantations in Gujarat and Maharashtra belonging to BAIF Development Research Foundation, Pune for consultancy.	20-25 February 2008
All Scientists	Meeting of demonstration farmers of the Centre.	16 August 2007
M.G.Nayak	Cashew seminar at Aswarapet, Kammam district, Andhra Pradesh.	29 October 2007
M.G.Nayak	International Horti. Expo at Pragathi Maidan, New Delhi.	30 January –2 February 2008
All Scientists, technical and administrative staff	Annual Cashew Day at NRCC, Puttur.	12 February 2008
M.G.Nayak	Agricultural awareness campaign organized by SKDRDP, Dharmasthala at Koila, Puttur taluk.	15 February 2008
M.G.Nayak	Agricultural awareness campaign organized by SKDRDP, Dharmasthala at Olamogru, Puttur taluk.	27 February 2008
M.G.Bhat	Kisan Mela organized by CPCRI Research Centre, Mohitnagar in connection with its Golden Jubilee Celebrations.	14 March 2008
M.G.Bhat	Cashew Field Day in Agricultural Research Station, Ullal, Mangalore.	19 March 2008

## 15. DELEGATION / TRAINING

R. Rejani	GIS based decision support systems for sustainable water resources management and precision agriculture held at NAARM, Hyderabad.	4-24 July 2007
T.N. Raviprasad	Hands-on training on Intelligent Reporting System (IRS) at NAARM, Rajendranagar, Hyderabad.	30-31 August 2007
D. Balasubramanian	Winter School on “Nondestructive and Biosensing methods for food safety and quality assurance” at Central Institute of Post Harvest Engineering and Technology, Ludhiana, Punjab.	6 - 26 September 2007
T.N. Raviprasad	Capacity Building for Intellectual Property Protection and Technology Licensing in Agriculture under the Indo-US Agriculture Knowledge Initiative held at Kerala Agricultural University, Thrissur.	18-20 February 2008.

## 16. DISTINGUISHED VISITORS

Sri. Kanwer Pal Chief Conservator of Forests KPTCL, Bangalore	17 May 2007
Dr. Sunitha Raju Professor IIFT, New Delhi	10 October 2007
Dr. M.V.R. Prasad Director (Retired) Directorate of Oilseed Research Hyderabad	10 October 2007

## 17. PERSONNEL

### Managerial

Director Dr. M.G. Bhat

### 17.1 Scientific

Discipline	Scientist	Scientist (Sr.Scale)	Sr.Scientist	Pr.Scientist	Total (Incl. vacant posts)
Agricultural Engg. (ASPE)			D. Balasubramanian	—	1
Agricultural Entomology	—	—	P.S. Bhat T.N. Raviprasad	D.Sundararaju	3
Agril.Extension	Vacant	-	—	—	1(1)
Biochemistry (Pl.Sci.)	—	—		KV Nagaraja	1
Biotechnology	—	—	—	Thimmappaiah (Gen.& Cyto.)	1
Computer Application	PD.Sreekanth *	—	—	—	1
Genetics and Cytogenetics	Vacant		Vacant	—	2(2)
Horticulture	Vacant	—	J.D. Adiga Vacant-1 post	M.G. Nayak	4 (2)
Plant Physiology	Vacant	—	—	—	1 (1)
Soil Science	—	—	—	N Yadukumar (Agr.)	1
Soil and Water Cons. Engg.	-	R. Rejani	—	—	1
Soil Science - Soil Physics and water conservation	—	—	—	Vacant	1(1)
Total	5(4)	1	6(2)	6(1)	18 (7)

\* On study leave for Ph.D.

Figures in the parantheses indicate number of vacant posts.

## 17.2. Technical

Sri. K.Muralikrishna	Farm Superintendent T(7-8)
Sri. P. Adbulla	Farm Superintendent T (7-8)
Sri. A.Padmanabha Hebbar	Technical Officer (Elec.) (T-5)
Sri. R.Arulmony	Technical Officer (lib.) (T-6 )
Sri. Prakash G Bhat	Technical 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 and	Technical Officer (T-5)
Sri. K.V. Ramesh Babu	Technical Officer (T-5)

A. Poovappa Gowda (T4) Ravishankar Prasad, K. Babu Poojary, Sri. Bejmi Veigus, Sri. K.K. Madhavan and Sri. K. Umanath (T 2).

## 17.3. Administration

Sri Ganesha	Assistant Finance and Accounts Officer
Sri.K.Sanjeeva,	Assistant Administrative Officer
Sri. K. Jayarama Naik,	Assistant Administrative Officer (Stores)

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

## 18. MISCELLANEOUS

### 18.1 Posting nursery information on NRCC, Website

Information about availability of more than 25 lakh cashew grafts produced in cashew nurseries of major cashew growing states were posted in NRCC, Website for the benefit of cashew growers all over the country.

### 18.2 Visitors

About 1000 visitors viz., farmers, Development Department officials were provided orientation about the research and development activities of NRCC, Puttur.

### 18.3 Consultancies

As per the request of BAIF Development Research Foundation, Pune, a team scientists from NRCC, visited the cashew plantations in Gujarat and Maharashtra during 20<sup>th</sup> – 25<sup>th</sup> February 2008 for offering consultancy. The team studied the main/ specific reasons for low yield of cashew in the project areas and suggested the measures to increase the yield to the projected levels.

As per the request of the Khanapur Cashew Growers Association, Bhatwada, Khanapur taluk , Belgaum district scientists from NRCC visited cashew plantations of the members of the association during February 2008. Recommendations were made to rectify the problems and increasing the productivity in the plantations visited.

#### 18.4 Weather data (2007-08)

Month	Temperature (°C)	Humidity (%)		Rainy days	Rainfall (mm)	Sunshine hours	Evaporation
	Max	FN	AN				
Apr. 07	36.8	90	49	5	82.8	6.4	4.6
May 07	34.5	90	59	3	52.2	6.7	4.1
Jun. 07	29.3	96	79	20	985.3	2.0	2.2
Jul. 07	28.9	96	86	35	1113.5	0.4	1.9
Aug. 07	29.8	94	79	23	690.2	2.2	2.1
Sept. 07	30.5	94	75	21	505.6	2.7	2.1
Oct. 07	32.0	93	67	13	281.6	4.8	2.8
Nov. 07	33.8	91	60	3	98.6	9.5	3.9
Dec.07	33.9	86	45	0	0.7	8.4	4.0
Jan. 08	34.3	94	48	0	0	9.8	4.6
Feb. 08	34.8	91	52	0	0.6	8.8	4.8
Mar.08	34.5	93	52	9	201.4	6.6	4.7

#### 18.5. LIST OF NRCC 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	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	Question and Answers regarding Cashew Cultivation (English)	31.00
6	Status of Cashew Germplasm Collection in India (Booklet)	
7	High Density Planting of Cashew (Booklet)	
8	Compendium of Concluded Research Projects (1986 – 2001)	
9	Indigenous Technical Knowledge in Cashew	
10	Sudharitha Geru Besaya Kramagalu (Booklet in Kannada)	15.00
11	Nutritive Value of cashew Revised (Brochure)	
12	Database on cashew nut processing in India (2003)	100.00
13	Directory of cashew nut processing industries in India (2003)	100.00
14	Process catalogue on development of economically viable on-farm cashew nut processing	45.00
15	Cashew cultivation practices (Pamphlet)	
16	Annotated Bibliography on Cashew 1995-2007	205.00

Price indicated above does not include postage.

Address your enquiries to the Director, NRCC, Puttur – 574 202, D.K., Karnataka.

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

