

वार्षिक प्रतिवेदन  
**ANNUAL REPORT**  
**2006-'07**

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



**NATIONAL RESEARCH CENTRE FOR CASHEW**  
(Indian Council of Agricultural Research)  
**PUTTUR - 574 202, DAKSHINA KANNADA**  
**KARNATAKA**



Correct Citation

**National Research Centre for Cashew**  
**Annual Report 2006-'07, Puttur, Karnataka, pp**

Published by

**Dr. M. Gopalakrishna Bhat**

Director

National Research Centre for Cashew

Puttur 574 202, DK, Karnataka

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

EPABX : 230902, 236490

Fax : 08251 - 234350

Gram : CAJUKENDRA

E-mail : [nrccaju@sancharnet.in](mailto:nrccaju@sancharnet.in), [nrccaju@rediffmail.com](mailto:nrccaju@rediffmail.com), [nrccaju86@yahoo.com](mailto:nrccaju86@yahoo.com)

NRCC Website : <http://www.nrccashew.org/>

AICRP Cashew : <http://www.nrccashew.org/indexl.htm>

Compiled and edited by

**Dr. K.V. Nagaraja**

**Dr. P. Shivarama Bhat**

**October 2007**

Word processed by

**Mr. R. Muthuraju**

Hindi Translation

**Dr. T.N. Raviprasad**

Hindi Text

**Mr. Prakash G.Bhat**

Cover Photo :

Printed at

**Codeword Process and Printers, Mangalore**

Ph. 2421418, 4261818

# CONTENTS

PAGE  
No.

**प्रस्तावना**

PREFACE

**कार्यकारी सारांश**

EXECUTIVE SUMMARY

INTRODUCTION

RESEARCH ACHIEVEMENTS

1. CROP IMPROVEMENT
2. CROP MANAGEMENT
3. CROP PROTECTION
4. POST HARVEST TECHNOLOGY
5. TRANSFER OF TECHNOLOGY
6. CONCLUDED PROJECTS

ADDITIONAL INFORMATION

# प्रस्तावना

(Hindi translation to be inserted)

## PREFACE

In this report , I am happy to present the achievements of the centre for the period from April 2006 to March 2007. The scientists of the centre have undertaken the research projects in the areas of Crop Improvement, Crop Management , Crop Protection, Post-Harvest Technology and Transfer of Technology as per the approved technical programme.

Six more accessions were planted in National Cashew Field Gene Bank (NCFGB), during the year, bringing the total accessions conserved so far to 506. A hybrid H-1250 (VRI-2 x VTH 40/1) was found promising under medium nut size category with an annual yield of 13 kg in 12<sup>th</sup> harvest and cumulative yield of 55.1 kg/tree for 12 harvests. A total of 42 elite varieties of cashew screened with nine selected primers of RAPD and the highest similarity was observed between Ullal-4 and H 32-4. Among the varieties, K-22-1 and V-6 were found as most divergent. The yield in the high tree density plots (416 and 500 trees/ha) was significantly more (726 and 1139 kg/ha) than in normal tree density plot (493 kg/ha). Soil and water conservation techniques like modified crescent bund or staggered trenches with coconut husk burial treatments had helped in conserving the soil moisture significantly and reduced the annual runoff.

Chlorpyriphos (0.2%) prevented reinfestation of treated trees to the tune of 80 per cent which was on par with higher concentrations of chlorpyriphos (0.4% and 0.6%) in the studies on post - extraction prophylaxis against Cashew Stem and Root Borer(CSRB). The GCMS analyses of volatiles collected from the virgin females of tea mosquito bug (TMB) revealed the presence of a compound, methyl butyrate.

The centre has initiated studies on nutraceuticals from cashew apples for the preparation healthy and speciality foods. The centre has strengthened its collaboration with DCCD, Kochi; SKDRDP, Dharmasthala; All India Radio, Mangalore; Doordarshan, Bangalore and Development Departments for intensifying transfer technology programme.

I am grateful to the members of the Editorial Committee for the compilation of this report . I welcome the suggestions of the readers of this report for improving output of our research efforts.

Place: NRCC, Puttur  
Date : 1<sup>st</sup> October 2007

**(M. Gopalakrishna Bhat)**  
Director

# सारांश

(Hindi translation to be inserted)

## EXECUTIVE SUMMARY

During the year, a total of 27 projects including two ad hoc projects and four observational trials were in operation at National Research Centre for Cashew Puttur. A total of four germplasm accessions collected from the Tsunami affected areas of Cuddalore districts of Tamil Nadu and two hybrids Raghava and Dhamodara received from Cashew Research Station, Madakkathara were added to National Cashew Field Gene Bank (NCFGB) raising the total germplasm conserved so far to 506. A hybrid H-1250 (VRI-2 x VTH 40/1) was found promising under medium nut size category with an annual yield of 13kg in 12<sup>th</sup> harvest and cumulative yield of 55.1 kg/tree for 12 harvests. 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 3<sup>rd</sup> harvest and cumulative yield of more than 12.5 kg (3 harvests) with the average nut size of more than 10 g. A total of 42 elite varieties of cashew screened with nine selected primers of RAPD and the highest similarity was observed between Ullal-4 and H 32-4. Among the varieties, K-22-1 and V-6 were found as most divergent. Similarly, the cashew germplasm accessions representing 10 morphological clusters were also screened based on both RAPD and ISSR markers. Accessions NRC-111 and NRC-112 had highest similarity coefficient (90%) while, NRC-142 and NRC-12 were highly divergent.

The yield in the high tree density plots (416 and 500 trees/ha) was significantly more (726 and 1139 kg/ha) than in normal tree density plot (493 kg/ha). Among the subplots (manurial doses), the yield increased 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 (704 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). Soil and water conservation techniques like modified crescent bund or staggered trenches with coconut husk burial treatments has helped in conserving the soil moisture significantly (15.7 and 14.8 % dry basis compared to 11.7 % dry basis in control). These treatments also reduced the annual runoff (15.7 % and 17.0 % of the annual rainfall compared to 30.8 % of the annual rainfall in control plot). 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. Beneficial micro organisms in terms of microbial biomass produced was also high in glyricidia and sunhemp plots.

The life table studies of Cashew Stem and Root Borer(CSRB) under laboratory conditions revealed that the mortality was higher during egg stage and for grubs aged < 15

days and between 15 and 45 days. Least mortality occurred in the older grubs aged between 120 and 150 days, > 150 days and among pupae. The survivorship curve was of type III or type IV of Slobodkin classification which indicated higher mortality in the younger stages. The GCMS analyses of volatiles collected from the virgin females of tea mosquito bug (TMB) revealed the presence of a compound, methyl butyrate. Kernels obtained from cashew nut samples collected from Tanzania, Madagascar and Mozambique were analysed for the presence of residues of insecticides in the cashew kernels. These were free from the residues of endosulfan and chlorpyrifos, lambda cyhalothrin and carbaryl. The survey conducted during off-season indicated that plant species such as *Cleome viscosa* (Fam: Capparidaceae) and *Oldenlandia umbellata* (Fam: Rubiaceae) (at coastal Tamil Nadu) and *Rungia repens* (Fam: Acantheceae) (at coastal Karnataka) supported all the bees during off-season.

Antioxidant activity in the methanol extract and its different fractions of autoclaved and dried cashew apple powder of released varieties was assessed by H<sub>2</sub>O<sub>2</sub> scavenging method. The variation was noticed for the H<sub>2</sub>O<sub>2</sub> scavenging activity, tannin, amino acid, phenols and reducing sugars.

As Transfer of Technology effort, Special training on “Cashew Production Technology” was organized for the officials of Karnataka Cashew Development Corporation. Several other training programmes on “Cashew Production Technology”, “Softwood Grafting Technique in Cashew”, and “Composting of Cashew Biomass” were organized. In these, 200 officials and members of Self Help Groups participated. Annual Cashew Day was organized at Kavu, Puttur taluk in a demonstration farmer’s field on 28-3-2007 in which around 300 farmers participated. The theme of the programme was “Increasing cashew yield through adoption of soil and water conservation techniques, drip irrigation and organic farming”. Training programme on “Cashew Apple Utilization” was also organized with financial support from DCCD, Kochi,

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 do 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 1053 books and 1500 back volumes of various journals. The library subscribes 33 National and 15 Inter – national 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 506 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 accessions .
- 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.
- In micropropagation, 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.
- 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 sloppy lands.
- High density planting (625 plants density/ha) was shown to be 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 has been standardized and its feasibility for the commercial multiplication has been demonstrated and this technique is being commercially utilized for large scale production of planting material in cashew in the country.
- Rearing technique for cashew stem and root borer (CSRB) on host bark has been standardized.
- Results from trial on phytosanitation confirmed the positive effect of phytosanitation in reducing the level of CSRB incidence in a given location.
- Chlorpyrifos (0.2%) was an effective chemical for post- treatment prophylaxis measures against CSRB.
- Studies have been taken up for the identification of kairomones of CSRB. Volatiles and extracts in hexane from both healthy bark and frass on testing by EAG elicited response from adult female beetles of CSRB.
- Laboratory rearing technique for tea mosquito bug (TMB) has been standardized. Among the new insecticides evaluated against the pest,  $\lambda$ -cyhalothrin was very 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 could be stored without quality deterioration for 12 months at ambient temperature.
- Defatted cashew kernel flour testa and cashew apple pomace of released varieties has been analysed for mineral composition and varietal variation noticed. 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 treatments of cashew apples resulted in the reduction of tannin of cashew apple powder prepared. 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.

- Impact of transfer of technology (TOT) was assessed and strategies were suggested for refining the TOT efforts.
- Yield forecasting model for predicting cashew yield was developed and refined.
- The centre has established very good linkage with farmers and officials of State Departments and Development Agencies related to cashew.

### Budget (2006-'07)

(Rs. In lakhs)

Plan	Non-Plan	External	Total
115.15	172.04	33.49	320.68

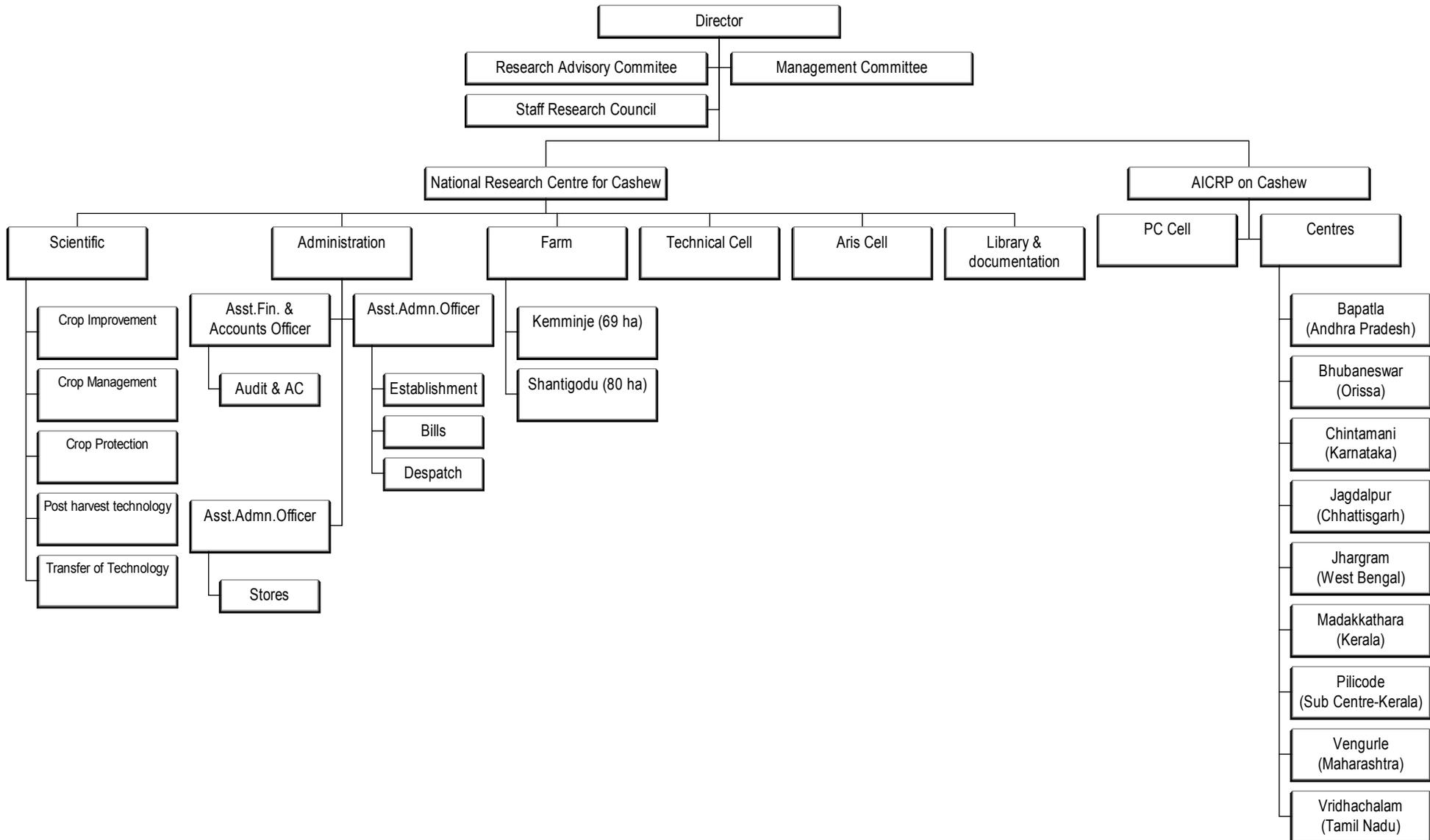
### STAFF POSITION AS ON 31.3.2007

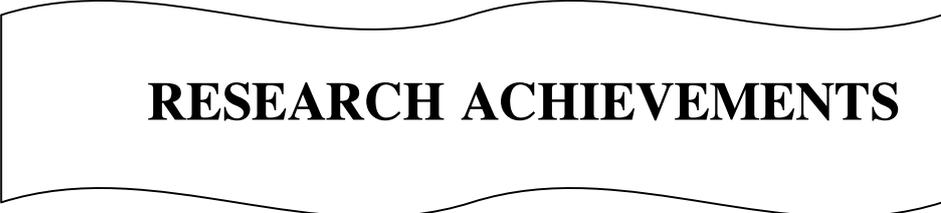
Category	NON PLAN			PLAN			TOTAL		
	Sanct- ioned	Filled	Vacant	Sanct- ioned	Filled	Vacant	No. of Posts	No. filled No.	Vacant
Director (RMP)	1	1	-	-	-	-	1	1	-
Scientific	18	11	7	-	-	-	18	11	7
Technical	19	18	1	4	-	4	23	18	5
Administrative	14	14	-	1	-	1	15	14	1
Supporting	41	39	2	-	-	-	41	39	2
Canteen	1	1	-	-	-	-	1	1	-
<b>Total</b>	<b>94</b>	<b>84</b>	<b>10</b>	<b>5</b>	<b>-</b>	<b>5</b>	<b>99</b>	<b>84</b>	<b>15</b>

### TOTAL MANPOWER

	Sanctioned	Filled	Vacant
Non Plan	94	84	10
Plan	5	-	5
<b>Total</b>	<b>99</b>	<b>84</b>	<b>15</b>

## ORGANISATIONAL SETUP OF NRC-CASHEW





**RESEARCH ACHIEVEMENTS**

# 1. CROP IMPROVEMENT

## 1.1 Genetic resources of cashew

### 1.1.1 Germplasm collection

During the year germplasm survey was undertaken in different districts of Andhra Pradesh and medium to bold nut type with high yield was identified for collection at Rayalkunta village in West Godavari district. Similarly, during survey in Kodagu district two bold nut with bunch bearing types were identified.

### 1.1.2 Germplasm conservation

During the year four germplasm accessions collected from the Tsunami affected areas of Cuddalore districts of Tamil Nadu and two hybrids Raghava and Dhamodara received from Cashew Research Station, Madakkathara were added to NCFGB raising the total germplasm conserved in the NCFGB to 506 (Table 1.1). The conservation block of gene bank has been established with 320 evaluated accessions by planting 4 plants of each accession at a closer spacing of 4m x 4m.

## 1.2 Varietal improvement of cashew

### 1.2.1 Evaluation of hybrids/selfs

Two promising hybrids namely H-46 (BPP-6 x A 18/4) and H 32/4 (BPP-5 x VRI-1) are under evaluation in the field of Karnataka Cashew Development Corporation (KCDC), Puttur Division (planted in 1999) and these plots are being regularly monitored. H 32/4 is also under testing in demonstration plots (planted in 1999 and 2001).

A hybrid H-1250 (VRI-2 x VTH 40/1) was found promising under medium nut size category with an annual yield of 13kg in 12<sup>th</sup> harvest and cumulative yield of 55.1 kg/tree for 12 harvests. In another trial H-2452 (BLA 139-1 x VTH 711/4) with last years yield 2.6 kg/tree in 8<sup>th</sup> harvests and cumulative yield of 29.9 kg from seven harvests were found promising.

Hybrids of several cross combinations were evaluated in hybrid graft trial at Shantigodu campus and a few hybrids appears to be promising for nut size and yield. They are 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). All these hybrids have above 5.5 kg yield in 3<sup>rd</sup> annual harvest with above 12.5 kg cumulative yield of 3 harvests with the average nut size of more than 10 g (Table 1.2).

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

## **1.3 Micropropagation**

### **1.3.1 Micropropagation for clonal root-stocks, somatic embryogenesis and rooting in cashew.**

#### **1.3.1.1 Micropropagation**

Nodal cultures from young cashew grafts of cashew elite and root stock varieties were established on hormone free semi-solid half-MS medium. Contamination was high during rainy season. Bud break varied from 11.1 – 51.6 per cent and shoot development in explants was from 3.6 – 22.3 per cent. Nodal cultures cultured alternatively on WPM medium containing NAA, IBA hormone (1 mg/l each) with other supplements and on hormone free WPM resulted in axillary shoot-bud proliferation (41.6%). After elongation on half-MS medium containing four per cent sucrose one of the multiple shoots showed rooting.

#### **1.3.1.2 Induction of somatic embryogenesis**

Nucellus cultures (1400 nos.) were initiated by culturing bisected ovules of 15 varieties on both Schenk and Hildebrandt (1972) medium containing various growth regulators (2, 4-D, NAA, BAP, picloram, spermine) in 10 combinations and on modified MS medium containing 2,4-D. Callus was observed in nucellus of all varieties and media. Variety showed significant effect on callus induction. Callus induction and growth was maximum (77.3 %) in Kanaka and least in BPP-6 (12.0 %). Induction of embryogenesis (5.5 to 41.8%) was observed in five varieties on both callus medium and on hormone free RBM medium with extra light. Kanaka had maximum SE induction of 41.8% followed by VRI-3.

Somatic embryos of Kanaka and BPP-6 were matured in dark on MS medium containing 20  $\mu$ M ABA, 100 mg/l AC, 1 g/l PVP-360 and 2.25 g/l phytigel. Germination of somatic embryos on RBM medium containing NAA, GA<sub>3</sub> and 1.5 per cent sucrose showed differentiation of both root and shoot system with scaly leaves. There was further improvement in shoot – morphology of SE's cultured on same basal medium containing NAA, GA<sub>3</sub> and BA. However, successful germination of SE's was achieved on RBM medium containing NAA, GA<sub>3</sub>, and BAP and with amino acids supplements like asparagines and L-glutamine.

#### **1.3.1.3 Evaluation of micropropagated plants in field**

Micropropagated plants (29+40) planted during 1997 and 1999 in two sets were evaluated for their growth characters like stem girth, plant height and spread (E-W and N-S) and also for their yield characters. There was significant difference among the treatments for growth characters as well as for yield. When growth performance between the different planting materials was compared only for plant height significant difference was observed. Micropropagated plants showed superior performance over grafts for yield characters. In the observational trial planted with variable number of tissue culture plants of four varieties, H 4-7 recorded the highest average yield (1.4 kg/tree) followed by VRI-1 (0.84 kg/tree) and TC dwarf was the poorest yielder (0.19/tree). Yield performance of micrografted plants and grafts in two varieties (Ulla-2 and NRC sel-1) was found to be on par.

## **1.4 Molecular characterisation of germplasm using RAPD and Isozyme markers**

### **1.4.1 DNA extraction from cashew accessions**

DNA was extracted from leaves of 68 accessions of cashew following CTAB buffer extraction procedure. Procedure for DNA extraction from dry leaf powder was also standardized. DNA quality was verified on 0.8% Agarose gel electrophoresis and quantified by recording absorption at 260 and 280nm. The yield obtained was on par with that of regular protocol (LN extraction). DNA purification was also standardized following the phenol : chloroform : Isoamyl alcohol extraction procedure.

### **1.4.2 PCR optimization and screening of ISSR/SSR primers for polymorphism**

PCR optimization was done for both ISSR and SSR markers with regard to concentration of various constituents (MgCl<sub>2</sub>, primer, dNTP's mix, Taq polymerase, template DNA and Taq buffer concentration) in the reaction mixture. Similarly amplification conditions were worked out. A total of 113 ISSR primers was got synthesized from OPERON technologies, USA, based on the primer sequences of British Columbia University were screened and observed amplification in 45 primers and polymorphism in 32 primers. A total of 21 pairs of SSR primers were got synthesized from OPERON technologies, USA, based on cashew gene sequence were screened for polymorphism. A total of 20 primer pairs showed amplification.

### **1.4.3 Screening of 42 varieties of cashew based on RAPD and SSR markers**

A total of forty two elite varieties including all the released varieties of cashew were screened using nine selected random primers of RAPD. A total of 63 bands were generated with 40 exhibiting polymorphism (68.5%). Among the primers tried, OPO-02 was found to be highly informative with polymorphic information content of 0.37 and marker index of 1.47. From the bands generated (binary data) Jacquard's (1908) similarity co-efficient was computed and a cluster diagram was made with UPGMA and the SHAN routine analysis in the NTSYS.PC 2.00 software. Highest similarity was observed between Ullal-4 and H 32-4. Among the varieties, K-22-1 and V-6 were found as most divergent.

Similarly 42 elite lines /varieties of cashew were characterized using 21 pairs of primers of SSR made based on cashew gene sequence. Out of 21 pairs of SSR primers 17 were polymorphic. Based on the allelic polymorphism observed on 3.5 per cent high resolution agarose similarity coefficient was computed and cluster analysis was made. From UPGMA dendrogram two major clusters could be made. One group had Bhaskara and VRI-3 and the second group had 40 varieties which could be divided into two smaller sub groups and minor clusters. The range of similarity was 0.58 to 0.97 and in this Ullal-4 and H 32-4 had highest similarity co-efficient (97%). VRI-3, Bhaskara and V-6 were found to be highly divergent.

### **1.4.4 Screening of cashew germplasm using RAPD and ISSR markers**

For this purpose, 10 primers each of RAPD and ISSR were selected and used for screening 60 accessions representing 10 morphological clusters. The percentage of polymorphism by combining RAPD and ISSR markers was 81.5 (110 out of 135 bands). Jaccard's similarity coefficient based on combined markers varied from 0.53 to 0.92. Highest has been observed between NRC-111 and NRC-112 and the lowest similarity

was observed between NRC-122 and NRC-66. Cluster analysis based on combined markers and similarity index revealed 9 to 10 smaller clusters at 70% similarity (Fig.1.1). The analysis revealed significant diversity in case of NRC-142 and NRC-12.

**Table 1.1: Germplasm holding in NCFGB, Puttur**

State	Number of accessions
	Total
Andhra Pradesh	102
Assam	3
Goa	45
Karnataka	126
Kerala	72 (2)
Maharashtra	45
Meghalaya	7
Orissa	21
Tamil Nadu	46(4)
Tripura	3
West Bengal	14
Exotic	22
Total	506(6)

Figures within parentheses indicate the number of accessions planted during 2006

**Table 1.2: Performance of promising hybrids in unreplicated trial**

Hybrid	Cross combination	Annual yield in 3 <sup>rd</sup> harvest (kg/tree)	Cumulative yield (kg/tree) for 3 harvests
H-66	NRCC Sel-2 x Bhutnath-II	5.98	14.46
H-68	NRCC Sel-2 x Bhutnath-II	5.53	13.90
H-43	NRCC Sel-2 x Bhutnath-II	6.05	14.18
H-125	NRCC Sel-2 x Bhedasi	6.88	13.90
H-126	NRCC Sel-2 x Bhedasi	6.77	12.80

**Table 1.3: Evaluation of performance of compact and dwarf genotype KGN-1 for plant growth characters in comparison to NRCC Sel-2**

Characters	KGN-1	NRCC Sel-2 (check variety)
Plant height (m)	3.9	3.98
Stem girth (cm)	39.67	45.2
Mean canopy spread (m)	3.61	4.06
Internodal length (cm)	2.70	2.21

## 2. CROP MANAGEMENT

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

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 in order to study the nutrient requirement per unit area.

#### 2.1.1 Ground coverage by the tree canopy

Ground coverage by the tree canopy in the high tree density plot was significantly more (39.95 and 49.45 % of the given area) than in normal tree density plot (21.6%). Among the subplots (manurial doses) significant difference was not observed. Interaction effect of density and fertilizer levels showed increased trend in combination of high tree density and medium and highest level of fertilizers (S2M2 and S3M3 significantly superior to rest of the combinations). Similarly , the combinations S3M2 and S3M3 are significantly superior to all the three densities with lowest fertilizer level and combination of lowest tree density with medium and higher levels of fertilizer (S1M2 and S1M3) (Table 2.1)

#### 2.1.2 Yield

The yield in the high tree density plots (416 and 500trees/ha) was significantly more (726 and 1139 kg/ha) than in normal tree density plot 493 kg/ha). Among the subplots, (manurial doses) the yield increased significantly as fertilizer level increased from M1 (704 kg/ha) to M3 (835 kg/ha) Interaction effect of tree density and fertilizer levels was not observed (Table 2.2).

### 2.2 Performance of high yielding varieties of cashew to 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 spacings (densities).The main objectives of the experiment are

- To determine optimum plant density for achieving highest yields and profit 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

#### Main plot

**Density** : (No. /ha, Spacing, m x m))

S1-200 (10mx5m), S2-312 (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.

The experiment was laid out after clear felling of the existing trees opening pits and planting nine cashew graft varieties.

## **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 cashew variety and 7 year old Bhaskara variety. The main objectives of the experiment are :

- Standardization of pruning technique to be subsequently followed in limb pruned and top worked trees to maintain high yield for a long period .
- Working out cost of maintaining limb pruned and top worked trees and profits realized subsequently for recommendation to the farmers.

**Design** : RBD,  
**Treatments** : 5  
**Replication** : 4  
**Plot size** : 2 plants per plot  
**Duration** : 5 years

### **Treatment details :**

- i) Pruning at 1 M height of the branches emerging after limb pruning (decrowning) or top working once in a year.
- ii) Pruning at 1 M height of the branches emerging after limb pruning or top working twice a year.
- iii) Pruning at 1 M height of the branches emerging after limb pruning or top working once in a year and application of pachlobutrazol @ 4ml a.i/tree/year.
- iv) Pruning at 1 M height of the branches emerging after limb pruning or top working once in a year and application of pachlobutrazol @ 8ml a.i/tree/once in two years.
- v) No further pruning after limb pruning – control.

## **2.4 Green manuring in cashew to increase productivity of cashew**

The experiment was started in 2001 and continued upto 2006-07. Both main and green manure crops were raised in 2001 and green manure crops like sunhemp, dhaincha were sown each year and glyricidia being perennial green manure crop seeds were sown in 2001 and only three cuttings per year were given. Four green manure crops namely sunhemp, dhaincha , glyricidia and cover crop (*Calapagonia mucunoides*) were grown in

between two rows of cashew planted at 4m x 4m distance. A control plot without growing green manure crops was also included. The treatments were replicated four times and laid out adopting RBD. Green biomass production was estimated and collected green biomass was applied back to the plot to improve soil fertility. Soil was analysed for nutrient contents on the year of start of the experiment and in 2006 to study the nutrient status.

In the long run glyricidia is more useful as green manure crop than sesbania due to the fact that sesbania green manure crop does not grow under the shade of cashew canopy which is evident from the fact that green biomass produced decreased over the years (Table-2.3) Green biomass produced from glyricidia is steadily increasing and total green biomass produced over the year is more in glyricidia plot. It is evident that soil organic carbon content and N content increased significantly in glyricidia plot compared to other plots (Table -2.4). Beneficial micro organisms in terms of microbial biomass produced is also high in glyricidia plot next to sunhemp plot.

Yield was highest in glyricidia and sesbania plot indicating growing glyricidia over the period upto seven years after planting is beneficial for improving soil fertility getting high yield (Table -2.5).

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

### **2.5.1 Evaluation of different soil and water conservation measures in relation to soil moisture availability and yield of cashew plantations grown in steep slopes**

This experiment was taken up to evaluate various soil and water conservation measures in relation to soil moisture, yield and economics and was laid out with treatments namely, modified crescent bund, staggered trenches with coconut husk burial between 2 rows of cashew, reverse terraces, catch pits 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. The soil moisture content, growth, yield and runoff data (using coshokton wheel and its accessories) were recorded.

#### **2.5.1.1 Runoff, soil loss and nutrient loss**

A rainfall of 3465 mm was recorded during May 2006 to April 2007. The annual runoff from coconut husk burial and modified crescent bund treatments were 15.7 % and 17.0 % of the rainfall compared to 30.8 % of the rainfall occurred in control plot. The annual soil loss recorded in staggered trenches with coconut husk burial and modified crescent bund treatments was 25-27% of the soil loss in the control plot. In reverse terrace treatment, it was 57% of the soil loss in the control plot. The nutrient loss from control plot was more compared to the treatment plots with soil and water conservation techniques.

Since the plots lie on the steep slopes of a barren hillock with eroded top soil, the major as well as minor nutrients present in the soil are very low. Most of the nutrients (major and minor) present in the soil in modified crescent bund treatment were more compared to control and all other treatments (Table 2.6).

### **2.5.1.2 Soil moisture content**

The soil samples at three depths (0-30 cm, 31-60 cm and 61-90 cm) were collected from base of the plant at 1.5 m radius using auger hole method during December 2006 to May 2007 (Table 2.7). The soil moisture contents (SMC) under the different treatments were determined using gravimetric method. No rainfall occurred from December 2007 to April 2007. In May, the soil samples were collected after a rainfall of 75 mm. The available soil moisture range was 12 to 22 per cent dry basis.

It was found that the SMC was high in the case of modified crescent bund treatment (16.9 to 21.5 % dry basis) and staggered trenches with coconut husk burial treatment (17.0 to 22.0 % dry basis) compared to control (15.6 to 18.4 % dry basis) during December 2006.

### **2.5.1.3 Soil moisture retention**

Modified crescent bund and staggered trenches with coconut husk burial treatments have conserved the maximum soil moisture. A mean soil moisture content of 3.3 to 4.6 per cent dry basis more than the control plot was observed in the case of modified crescent bund and staggered trenches with coconut husk burial treatment during January 2007. The soil moisture content in the top layer of 0-30 cm depth was almost same in all plots including control (12.0 to 12.8 % dry basis in soil and water conservation treatments and 11.1 % dry basis in control) during February 2007. But in the lower layers, the SMC was 3.6 to 5.2 per cent dry basis more than the control plot in the case of modified crescent bund and staggered trenches with coconut husk burial treatment.

It was found that the SMC in all the three layers of soil in the treatments namely, modified crescent bund, staggered trenches with coconut husk burial and reverse terrace were in the available soil moisture range and the SMC in the first two layers of soil in the control plot was below the available soil moisture range in March itself. The increased soil moisture content in the lower layers of the soil in the soil and water conservation treatment plots (22.4 to 24.1 % dry basis compared to 19.1 to 19.8 % dry basis in control) during March 2007 shows the effectiveness of soil and water conservation techniques in conserving the pre-monsoon rainfall.

### **2.5.1.4 Growth and Nut Yield**

Maximum stem girth [modified crescent bund treatment – 41.5 cm and control – 36.0 cm] and canopy spread [modified crescent bund treatment – 3.88 m and control – 2.93 m] was observed in the case of plants in modified crescent bund treatment compared to control and all other treatments. A trend of increased cumulative yield in the first and second harvest was also observed in the case of staggered trenches with coconut husk burial (1092 kg/ha) and modified crescent bund (1026 kg/ha) compared to control (713 kg/ha) plot without any soil and water conservation structures (Fig.2.1).

**Table 2.1: Ground coverage by canopy (%) (6 years after planting)**

Treatment	Low dose (M1)	Medium dose (M2)	High dose (M3)	Mean
S1 = 200 plants/ha	21.92	21.43	21.04	21.46
S2 = 416 plants/ha	40.49	39.77	39.61	39.95
S3 = 500 plants/ha	38.38	55.33	54.7	49.43
Mean	33.59	38.81	38.45	Mean
CD (5%) for Density				6.96
CD (5%) for Manure				NS
CD (5%) for DxM				8.82

**Table 2.2: Yield in kg/ha 6 Years after planting**

Treatment	Low dose (M1)	Medium dose (M2)	High dose (M3)	Mean
S1 = 200 plants/ha	558	464	458	493
S2 = 416 plants/ha	628	745	807	726
S3 = 500 plants/ha	927	1251	1240	1139
Mean	704	820	835	
SED for Density				81
CD (5%) for Density				200
SED for Density				63
CD (5%) for Manure				NS
CD (5%) for DXM				NS

**Table 2.3: Green biomass yield (t/ha) of green manure crops in cashew garden**

Green manure crops	Dry wt. of GBM 2002	Dry wt. of GBM 2003	Dry wt. of GBM 2004	Dry wt. of GBM 2005	Mean of 4 years
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

GBS=Green biomass

**Table 2.4: Effect of green manure crops on soil nutrient contents 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	1.14	124	27	84	261
Sesbania	1.25	141	22	100	168
Glyricidia	1.35	150	21	60	229
Cover crop	0.77	87	19	97	149
No GM	0.68	76	10.5	80	160

**Table 2.5: Effect green manure crops on cashew yield (kg/ha) over years**

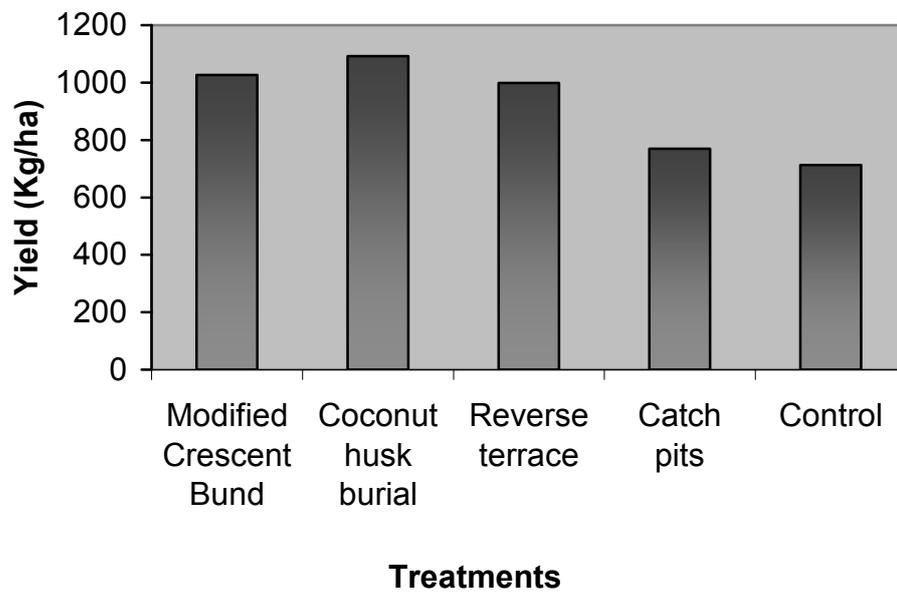
Crop combinations	2004	2005	2006	Mean yield of 3 years
Cashew+Sunhemp	469	658	820	649
Cashew +Sesbania	794	856	925	858
Cashew +Glyricidia	543	845	1048	812
Cashew +Cover crop	509	640	879	676
Cashew alone	400	504	845	583
SED				47
CD (5%)				102

**Table 2.6: Nutrient status of the soil in different treatment plots (January 2007)**

Treatments	N (kg/ha)	P (kg/ha)	K (kg/ha)	Ca (kg/ha)	Mg (kg/ha)	Cu (mg/kg)	Zn (mg/kg)	Mn (mg/kg)
Staggered trenches with coconut husk burial	190.58	4.38	28.91	6.54	1.99	0.22	3.23	1.38
Modified crescent bund	194.00	7.08	25.18	9.7	2.83	0.14	4.53	1.5
Reverse terraces	165.26	3.18	19.70	8.30	3.52	0.17	4.10	1.95
Catch pits	157.79	3.20	17.63	18.65	5.56	0.09	5.51	1.17
Control	143.00	2.72	17.67	8.67	2.37	0.10	1.81	0.80

**Table 2.7: Mean soil moisture availability (% db) under different treatments (Jan – April 2007)**

Treatments	Mean soil moisture (% dry basis)			
	Jan	Feb	Mar	Apr
Modified crescent bund	19.2	17.8	15.7	14.9
Staggered trenches with coconut husk burial between 2 rows of cashew	19.5	16.9	14.8	14.3
Reverse terraces	19.0	16.6	13.8	13.2
Catch pits	17.5	15.7	11.9	11.5
Control plot without any soil and water conservation measure	17.0	12.7	11.7	11.3
<b>CD (5%) - Treatment</b>	<b>1.54</b>	<b>1.51</b>	<b>1.56</b>	<b>0.93</b>
<b>CD (5%) - Depth</b>	<b>0.39</b>	<b>0.42</b>	<b>0.45</b>	<b>0.47</b>



**Fig. 2.1: Cashew yield in different soil and water conservation treatments (2 harvests)**

### 3. CROP PROTECTION

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

##### 3.1.1 Studies on Post Extraction Prophylaxis (PEP)

This trial was conducted from 2000-06 in various experimental plots of Kemminje and Shantigodu campus as well as in the demonstration plots at Shantigodu. Initially carbaryl (1%), monocrotophos (0.2%), lindane (0.2%), chlorpyrifos (0.2%) and untreated control (only removal of grubs) were evaluated to identify the most suitable insecticide for preventing reinfestation by CSRB. Of the insecticides tested chlorpyrifos (0.2%) could prevent reinfestation to the tune of 86.62 per cent followed lindane (0.2%) [77.51%] and monocrotophos (0.2%) [70.83%] whereas carbaryl (1.0%) could prevent reinfestation in only 68.36 per cent of treated trees. Reinfestation did not occur in 47.2 per cent of treated trees even without insecticidal treatment after removal of grubs and other pest stages (Table 3.1). As lindane was withdrawn from agricultural usage, chlorpyrifos and monocrotophos were evaluated in further trials during 2003-06.

In the second trial chlorpyrifos (0.6%) could check reinfestation in 85.8 per cent of treated trees which was the highest and was on par with chlorpyrifos (0.4%) which prevented reinfestation in 81.7 per cent of treated trees. However, chlorpyrifos (0.2%) could prevent reinfestation of treated trees to the tune of 80.1 per cent which was on par with the other two higher concentrations of chlorpyrifos as well as with the higher concentrations of monocrotophos. All the three concentrations of monocrotophos (0.2, 0.4 and 0.6 per cent) were significantly less effective than chlorpyrifos (Table 3.2).

In order to understand the survival rate of different instars and to schedule the plant protection activity the life tables of CSRB was constructed under laboratory conditions. The eggs obtained from lab cultured CSRB was observed for percentage of hatching and later instars were reared on cashew bark individually in rearing bottles. Observations were made on mortality in different instars and the expectation of life ( $e_x$ ) for each instar as well as type of survivorship curve was constructed (Fig. 3.1). It was observed that the mortality was higher during egg stage and for grubs aged < 15 days and 15-45 days. Least mortality occurred in the older mature grubs aged 120-150 days and > 150 days as well as among pupae. The survivorship curve was of type III or type IV of Slobodkin classification which indicated higher mortality in the younger stages (Table 3.3).

#### 3.2 Survey for incidence of storage pests on cashew nuts and kernels

Various cashew processing industries situated in Puttur, Sullia, Mangalore, Karkala and Ajekar were visited for obtaining information on incidence of different storage pests. It was noticed that majority of the processors in Puttur, Mangalore and Karkala adopted contractual pest management in their premises during off-season.

The insect pests noticed were *Tribolium castaneum*, *Ephestia cautella* and *Rhyzopertha dominica*. The incidence of these pests was very minimal and was restricted to few factories. The occurrence of *Tribolium castaneum* was most commonly noticed in large numbers on rejects and testa stored in the ware houses. *Ephestia cautella* was noticed in the packing section, and in certain cases the tin packing which was sent for repacking to cashew exporting firms had moderate incidence of this pest. *Rhyzopertha dominica* was noticed both in the peeling and packing section in few factories.

In general all the cashew processing firms adopted good to high level of hygienic practices and did not encounter significant damage on nuts or kernels due to incidence of storage pests.

Most of the processors were not aware of the insecticide being used by the pest management firms. Certain processors used chlorpyrifos and synthetic pyrethroids for managing ants and termites. In cashew processing industries located in Ajekar hanging of paper strips dipped in castor oil was a common practice to manage *Ephestia cautella* during early monsoon season (Table 3.4).

### 3.3 Lepidopteran flower and fruit pest of cashew

In order to find out the yield loss due to flower and fruit pests, 110 paired panicles on 7 to 10 days after initiation of flowering were tagged at random on eight trees and half of the numbers of panicles were protected with  $\lambda$ -cyhalothrin treatment as dip method twice at three weeks interval. The untreated panicles were excluded from tea mosquito (TMB) by mechanical killing on every day. On 60th day, as all pairs of panicles were free from TMB attack, all 110 pairs of panicles were finally observed to record final harvestable fruit set after the impact of flower pests. The protected panicles recorded  $4.33 \pm 0.33$  (S.E)-fruits/panicle whereas unprotected panicle having flower pest damage recorded only  $1.66 \pm 0.24$  fruits/panicle (Table 3.5). Thus in the absence of TMB attack, with timely protection of lepidopteran flower pests alone lead to one and a half times increase in yield.

Two insecticides ( $\lambda$ -cyhalothrin 0.003% and carbaryl 0.1%) recommended for management of tea mosquito bug were sprayed in a large plot containing 110 trees with three rounds of sprays. Immediately after first, second and third sprays, the numbers of flower infesting caterpillars were collected by drop cloth method at the ground level of the tree. Six hours after spread of cloth, the larvae fallen on the cloth were counted. Flower infesting caterpillars were collected only after second spray and 0.25 & 2.44 caterpillars per square meter were collected in cyhalothrin and carbaryl treatments respectively indicating the overall build up of population of the pest. The population composition was analysed after second spraying with cyhalothrin and carbaryl. In the cyhalothrin and carbaryl sprayed plots, the shoot dip caterpillars and other flower feeding caterpillars were observed in the ratio of 1.0 : 0.7 and 1.0 : 1.6 respectively (Table 3.6). Further, during 2005-06 cropping season, after first and third round of spray, not even single caterpillar was collected on the drop cloth indicating its absence during initial flushing as well during fruiting.

The apple and nut borer (*Thylacoptila paurosema*) was recorded for the first time on a new weed host plant (*Cassia alata*, Candlebrush, an ornamental plant introduced from Argentina) occurring in the cashew plantations. The damage was noticed from both flower bud candle and developing fruits during October –November 2005. Most of insect specimens collected so far were identified through KFRI, Peechi, Kerala as identification service was not available at IARI, New Delhi & IIE, London. Based on the nature of damage, they were classified as major and minor pests as given Table 3.7.

### 3.4 Foraging behaviour of pollinators of cashew

The extent of pollination was assessed by observing deposit of pollen grains on the stigma of hermaphrodite flowers. The extent of pollination was assessed for the third consecutive season on seven varieties (V-1, V4, NRCC-2, Bhaskara, Ullal-3, Dhana, & Vri-3). The extent of pollination ranged from 27.0 to 49.4 per cent and extent of pollen

deposit as no. of pollen grains per stigma ranged from  $1.9 \pm 0.35$  (S.E) to  $3.09 \pm 0.49$  (S.E) (Table-3.8).

The extent of fruit set under caged condition (insect pollinators excluded) was assessed. For this purpose, mosquito net sleeve cages were fabricated and caged. In VRI-3 variety (low to medium cluster bearing variety), five leader shoots (each leader shoot consisted more than flowering lateral shoots) and fifty lateral flowering shoots were individually caged just on the day onset of flowering or just one day prior to onset of flowering in respective panicle. Similarly in V-4 (cluster bearing variety), one leader shoot and five flowering lateral shoots were caged individually for comparison. Every day at 2 PM, each cage was gently tapped to simulate as shaking of panicles by wind and thereby the fall of pollen grains by gravity was induced. The results indicated that in VRI-3 variety, fruit set was observed only in some of the cages, whereas in V-4, fruit set was observed in all the cages. This study clearly indicated that in cashew geitonogamous pollination through wind induced gravity fall of pollen grains under overlapped situation was also occurring besides regular insect pollination.

Visit of pollinators at fixed hours and fixed spot on cashew (flowering season) and other plants (off-season) were made during this year. For this purpose one square meter of the canopy was marked in early season (NRCC-2), mid season (Bhaskara) and late season (Chintamani- 1) flowering varieties. In each variety, the visits of pollinators at fixed hour (11.0 AM and 2.0 PM) were observed for a period of 10 minutes continuously for 30 days from initiation of flowering among panicles. The results indicated that the early, mid and late season varieties had recorded visit of bees as 0.35, 0.16 and 0.09 pollinator/ panicle/day respectively. On NRCC-2, the main pollinator visited was found to be stingless bee (*Trigona irridipennis*), whereas on Bhaskara, the short tongued bees (non-*Apis* spp.) visited highest and on Chintamani, both *T. irridipennis* and short tongued bees visited as main pollinators. At same time when the population of bees visiting neighbouring avenue flowering tree (*Pheltophorum ferruginium*) was observed, it was found that *T. irridipennis* visited as 13.5/ panicle (as instant count) (Table 3.9). Thus, cashew had a very low visit of bees when compared to other high nectar producing tree.

The survey conducted during off-season indicated that plant species such as *Cleome viscosa* (Fam: Capparidaceae) and *Oldenlandia umbellata* (Fam: Rubiaceae) (at coastal Tamil Nadu) and *Rungia repens* (Fam: Acantheceae) (at coastal Karnataka) supported all the bees during off season.

Immediately after first, second and third round of spray, mortality of pollinators was assessed by drop cloth method as described above. Even after six hours of spray, no dead bees were observed on the drop cloth. Further, the apiaries near the vicinity of sprayed plots were also observed for mortality of bees and no mortality of honeybees could be seen. But in a plot of NRCC-2 where activities of *T. irridipennis* was seen in a high level, a general spray of  $\lambda$ - cyhalothrin 0.003% was given and after the spray, its activities ceased on that particular day of spraying only and subsequently resumed on next day itself. Similar trend was also seen for *Apis cerana indica* which generally visits cashew at a low level only. But with regard to *A.florea*, on the day of spraying, stray death of bees was seen in the plot itself and subsequently its visit was sighted only after fifteenth day of spraying.

### **3.5 Studies on the determination of insecticide residues in cashew kernels**

Kernels obtained from cashew nut samples collected from Tanzania , Madagascar and Mozambique were analysed for the presence of residues in the cashew kernels. Residue of endosulfan and chlorpyrifos were not detected at the detection limit of 10ppb. The residues of lambda cyhalothrin and carbaryl were not detected at detection limit of 100ppb. The analyses of the samples were done in collaboration with Cashew Export promotion Council of India (CEPCI), Quality Control, laboratory, Kollam.

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

#### **3.6.1 Evaluation of spray oil**

Spray Oil supplied by M/S Indian Oil Corporation, Mumbai was evaluated against TMB under field condition and 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 0.97-1.07 in spray oil treatment compared to 0.22 in  $\lambda$ - cyhalothrin.

#### **3.6.2 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 and 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 in 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 insecticides  $\lambda$ - cyhalothrin (0.003%). The damage rating was 0.27 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 average number of predators/panicle ranged from 0.82 – 1.00 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.

**Table 3.1: Percentage of trees without re-infestation by CSRB under PEP trials (2000-03)**

Insecticides evaluated	Percentage of trees without re-infestation
Carbaryl (1%)	68.36 b
Monocrotophos (0.2%)	70.83 b
Lindane (0.2%)	77.51 a
Chlorpyriphos (0.2%)	86.62 a
Untreated control (only removal of grubs)	47.17 c
SE	9.881
CD (5%)	9.248

**Table 3.2: Percentage of trees without re-infestation by CSRB under PEP trials (2003-06)**

Insecticides evaluated	Percentage of trees without re-infestation
Chlorpyriphos (0.2%)	80.10 ab
Chlorpyriphos (0.4%)	81.68 a
Chlorpyriphos (0.6%)	85.76 a
Monocrotophos (0.2%)	68.06 c
Monocrotophos (0.4%)	72.90 bc
Monocrotophos (0.6%)	79.56 ab
SE	8.645
CD (5%)	8.673

**Table 3.3: Life table of CSRB under lab conditions**

x	$l_x$	$d_x$	$L_x$	$T_x$	$e_x$	1000 $q_x$
Eggs	1000	675	663	2195	2.19	675
(< 15 days)	325	84	283	1532	4.71	258
(15 – 45 days)	241	43	220	1249	5.18	178
(45 - 90 days)	198	8	194	1029	5.19	41
( 90 - 120 days)	190	2	189	835	4.39	11
(120 - 150 days)	188	1	187	646	3.44	5
(> 150 days)	187	1	186	459	2.45	5
Pupae	186	7	183	273	1.47	37
Adults	179	179	90	90	0.51	1000

**Table 3.4: Details of pest infestation observed in cashewnut processing units**

No. of Cashewnut processing units visited		Storage pests encountered or reported by the processors			
		<i>Tribolium castaneum</i>	<i>Ephestia cautella</i>	<i>Rhyzopertha dominica</i>	Ants / Termites
Puttur	4	2	1	-	1
Sullia	3	2	2	1	2
Mangalore	7	3	-	2	-
Karkala	8	2	2	-	5
Ajekar	6	-	4	1	3

**Table 3.5: Yield loss assessment due to lepidopteran flower and fruit pests**

Details	Protected	Unprotected
No. of panicles tagged at random	110	110
No. of panicles without TMB damage	110	110
% of panicles had harvestable fruit set	86.4	56.4
% increase over unprotected	53.2	-
Mean no. of harvestable fruits per panicle	4.33±0.33 <sup>a</sup>	1.66±0.24 <sup>b</sup>
Relative variation (%) of harvestable fruits	7.62	14.46
Range of harvestable fruits per panicle	0-17	0-17
% fruit borer damage	0.0	0.6

± Values are Standard Error. In the row, values followed by different letters indicates significant difference by Student's 't' test at 1.0% level.

**Table 3.6: Evaluation of promising insecticides against flower pests in large plot trial**

Treatment	Flower infesting caterpillars* (no./m <sup>2</sup> ) after			Species composition (Shoot tip caterpillars : others)
	1 <sup>st</sup> spray	2 <sup>nd</sup> spray	3 <sup>rd</sup> spray	At 2 <sup>nd</sup> spray
Carbaryl 0.1%	0.00	2.44	0.00	1.0 : 1.6
λ-cyhalothrin 0.003%	0.00	0.25	0.00	1.0 : 0.7
Control	N.R	N.R	N.R	

\* Estimated by drop cloth method.

**Table 3.7: List of pests recorded at coastal Karnataka and coastal Tamil Nadu.**

Coastal Karnataka	Coastal Tamil Nadu
<b>Major Pests :</b> Shoot tip caterpillars, <i>Hypatima haligramma</i> M. and <i>Anarsia epotias</i> M.	Shoot tip caterpillars, <i>Hypatima haligramma</i> M. and <i>Anarsia epotias</i> M.
Apple and nut borer, <i>Thylacoptila paurosema</i> M.	Apple and nut borer, <i>Thylacoptila paurosema</i> M.
Unidentified noctuid	Leaf and blossom webber, <i>Lamida moncusalis</i> W.
<b>Minor Pests :</b> <i>Archips</i> spp.*; <i>Rapala</i> sp.*; <i>Aetholix flavibasalis</i> *; <i>Oenopsila flavifuscata</i> , <i>Pingasa ruginaria</i> , <i>Anigrea albomaculata</i> , <i>Euproctis scintillans</i> , <i>Lamida moncusalis</i> and Three unidentified pyralids.	<i>Sylepta balteata</i> , <i>Euproctis scintillans</i> and one unidentified noctuid.

**Table 3.8: Extent of pollination in different varieties of cashew**

Variety/ Accession	Extent of pollination (%)#	Deposit of pollen grains		% pollen grains deposited as 1-2 grains
		no./stigma $\pm$ S.E	R.V(%)	
Vengurla-1	48.3	2.72 $\pm$ 0.41	14.9	66.0
Vengurla-4	38.8	2.46 $\pm$ 0.33	13.5	65.7
Bhaskara	46.4	2.49 $\pm$ 0.28	11.3	63.3
NRCC-2	35.1	2.06 $\pm$ 0.19	9.43	73.7
Ullal-3	27.0	3.09 $\pm$ 0.49	15.8	66.7
Dhana	36.2	1.90 $\pm$ 0.35	18.4	84.9
Vridhachalam-3	49.4	2.90 $\pm$ 0.39	13.6	66.7

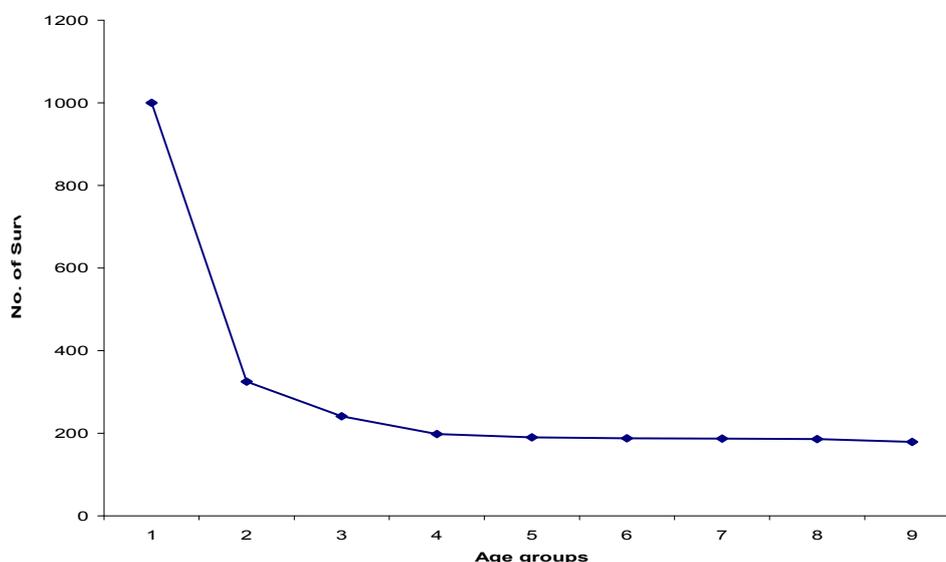
# Observed through stereoscopic dissection microscope  
R.V – Relative variation ( % of S.E)

**Table 3.9: Visitation by bees on cashew and common avenue tree**

Categories of bees	Visit of bees within 10 minutes(no./panicle/day) during 30 observational days			Instant visit of bees on common avenue tree* (no./panicle/day)
	NRCC-2	Bhaskara	Chintamani	
Stingless bee ( <i>Trigona irridipennis</i> )	<b>0.280(30)</b>	0.003(3)	0.036(8)	<b>13.50(30)</b>
<i>Apis cerana indica</i> (honey bee)	0.027(14)	0.026(10)	0.014(11)	0.07(30)
<i>A. florea</i>	0.025(17)	0.007(3)	0.000	0.00
Non- <i>Apis</i> spp.	0.021(9)	<b>0.136(26)</b>	<b>0.036(16)</b>	0.00
Total	0.353(30)	0.162 (26)	0.086(27)	13.57(30)

\* *Pheltophorum ferruginium*

Figures in brackets indicate the no. of days sighted out of 30 observational days.



**Fig. 3.1: Survivorship curve of CSRB under lab conditions – host bark**

## 4. POST HARVEST TECHNOLOGY

### 4.1 Nutraceuticals

Antioxidant activity in the methanol extract and its different fractions of autoclaved and dried cashew apple powder of released varieties was assessed by H<sub>2</sub>O<sub>2</sub> scavenging method. The variation noticed for the H<sub>2</sub>O<sub>2</sub> scavenging activity, tannin, amino acid, phenols and reducing sugars is presented in Table 4.1. Significant varietal variation has been observed for the antioxidant activity, tannin, amino acid, sugars and phenols contents. Maximum antioxidant activity was noticed in variety V-4 while it was minimum in variety Anagha. The antioxidant activity in amino acid (1.38), phenols (0.758) and sugar fraction (0.757) was maximum in varieties Sulabha, Kanaka and Selection-2 respectively.

Antioxidant activity and associated biochemical changes in the composition of cashew apple powder prepared under different conditions was studied during storage at ambient temperature. Changes in the moisture content, ascorbic acid, tannin, phenols, peroxides, reducing sugars, amino acid and antioxidant activity in methanol extract and its different fraction was followed during storage of cashew apple powder at ambient temperature (Table 4.2). During the storage period upto 12 months, moisture content and peroxides increased while ascorbic acid, phenols, amino acid, DPPH scavenging activity and Potassium ferricyanide reduction decreased in all the samples. However, tannin and reducing sugar contents did not change much during storage.

**Table 4.1 Variability for H<sub>2</sub>O<sub>2</sub> scavenging activity and composition of methanol extract of cashew apple powder of released varieties.**

Composition	Variability		
H <sub>2</sub> O <sub>2</sub> scavenging activity (m mols H <sub>2</sub> O <sub>2</sub> scavenged/10 min/100 mg) Methanol fraction	1.905 (Anagha)	-	8.628 (V-4)
Sugar Fraction	0.078 (Madakkathara-1)	-	0.757 (Sulabha)
Amino acid Fraction	0.121 (Bhaskara)	-	1.382 (Kanaka)
Phenol Fraction	0.14 (Chintamani-1)	-	0.758 (Sel-2)
Tannin(Methanol Fraction) mg/100 mg	0.194 (BPP-1)	-	0.575 (V-3)
Amino acids (mg/100 mg)	0.161 (Anagha)	-	1.98 (V-1)
Phenols (µg/100mg)	8.42 (V-7)	-	61.17 (Sel-1)
Reducing sugars (mg/100 mg)	3.56 (V-5)	-	24.83 (Amrutha)

**Table 4.2. Biochemical changes during storage of cashew apple powder at ambient temperature.**

Composition	Storage period (months)	A	B	C	D
Moisture (%)	0	4.84	4.18	3.64	2.56
	12	13.11	13.78	9.05	9.85
Ascorbic acid ( $\mu\text{g}/100\text{ mg}$ )	0	83.19	137.02	168.35	75.09
	12	20.74	21.63	13.95	13.98
Tannin ( $\mu\text{g}/100\text{ mg}$ )	0	310.67	257.05	187.14	240.18
	12	311.00	253.00	252.00	228.0
Phenols ( $\mu\text{g}/100\text{ mg}$ )	0	87.79	87.26	33.14	52.95
	12	34.21	32.97	22.26	25.46
Peroxides (n mols/100 mg)	0	4.46	4.6	1.79	2.35
	12	16.23	15.74	6.22	8.37
Reducing sugar (mg/100 mg)	0	14.34	16.63	9.05	8.00
	12	7.54	16.17	9.67	6.88
Amino acid (mg/100 mg)	0	19.86	24.53	6.36	10.2
	12	1.66	1.15	1.31	1.37
<b>DPPH activity (<math>\mu\text{ moles}/100\text{ mg}</math>)</b>					
Methanol extract	0	2.03	2.34	2.2	1.15
	12	1.25	1.32	0.93	0.26
Amino acid fraction	0	1.02	1.06	1.04	1.03
	12	0.45	0.64	0.38	0.29
Phenol fraction	0	0.146	1.02	1.04	1.45
	12	Nil	Nil	Nil	Nil
Oxalic acid extraction (Vit C)	0	1.88	2.34	5.52	4.42
	12	1.65	1.73	10.14	8.63
Potassium ferricyanide reduction ( $A_{700}/20\text{ min}/100\text{ mg}$ )					
Methyl Extrac	0	40.52	48.57	39.26	39.71
	12	27.05	26.63	25.67	25.23
Amino acid fraction	0	5.34	10.17	7.35	9.03
	12	2.62	3.59	2.43	2.44
Neutral fraction	0	42.29	26.7	22.91	26.58
	12	2.43	2.31	1.105	2.064
Phenol fraction	0	2.42	2.87	2.59	2.3
	12	0.786	0.399	0.591	0.258

- A - Cashew apple powder Red
- B - Cashew apple powder Yellow
- C - Salt + Potassium metabisulphate treated autoclaved & dried (Yellow)
- D - Salt + metabisulphate treated and dried (Yellow)

## 5. TRANSFER OF TECHNOLOGY

### 5.1 Monitoring of demonstration plots

Regular visits were made by the team of Scientists to the demonstration plots laid out with the financial support of DCCD, Kochi in the farmers' fields. The conditions of the plots were assessed and the farmers were provided with appropriate technical guidance. The yield data of the different plots were also collected. The mean yield of the demonstration plots laid out with high density planting system was 1.7 times more than that of normal density plots.

### 5.2 Organizing farmers training programmes

During the year the following training programmes were organized

Name of the programme	Date	Collaboration	No. of participants
"Cashew Apple Utilization" for farm women	25/4/2006	SKDRPD, Puttur	45
Off-campus training programme on "Cashew Production Technology"	23/6/2006	SKDRPD, Puttur	30
Off-campus training on "Establishment and management of Cashew Orchards"	14/7/2006	SKDRPD, Puttur	40
"ICAR Foundation Day" – Demonstration farmers meet	17/7/2006	-	60
Softwood grafting technique in cashew	26/9/2006	-	13
Thematic campaign on "Plant Protection in Cashew"	27/11/2006	Nagarika Seva Trust	60

### 5.3 Organizing trainers' training programmes

During the year the following training programmes were organized for the officials of development departments:

Name of the training programme	No. of participants	Sponsored by
Special training on "Cashew Production Technology" (1-5, August, 2006)	30	KCDC Ltd., Mangalore
Softwood Grafting Technique in Cashew (22-23, August 2006)	12	APFDC Ltd., Andhra Pradesh; TNPPC Ltd., Tamil Nadu; Dept. of Agriculture, Maharashtra; M/s Mahesh Nursery, Mangalore
Pruning in Cashew and "Composting of Cashew Biomass" (14-16, December., 2006)	24	DOA, Kerala; APFDC Ltd., Andhra Pradesh; TNFPC Ltd., Tamil Nadu; KCDC Ltd., Mangalore; SKDRDP, Dharmasthala
Cashew Production Technology – Refresher course	9	Department officials from Karnataka, Kerala, Andhra Pradesh and KCDC.

## **5.4 Annual Cashew Day**

Annual Cashew Day was organized at Kavu ,Puttur taluk in a demonstration farmer's field on 28-3-2007. The theme of the programme was "Increasing cashew yield through adoption of soil and water conservation techniques, drip irrigation and organic farming". More than 300 farmers from Dakshina Kannada, Udupi and Kasaragod district participated in the programme. Farmers were taken to demonstration plots of four different farmers and explained about different technologies. A seminar was also organized in which farmers were also given the opportunity to share their experience in cashew.

## **5.5 Mass media utilization**

In collaboration with DD-Chandana, important aspects on cashew cultivation were produced as video programmes and were telecast through DD-Chandana. A data collection tool for assessing the mass media utilization behaviour of cashew growers was standardized.

## **5.6 Socio-economic impact of cashew cultivation – Cuddalore district**

### **5.6.1 Cashew in Cuddalore district**

Visits (2 nos) were made to Cuddalore district of Tamil Nadu to assess the socio-economic impact of cashew cultivation. The district has a coastal line of about 57.5 km suitable for plantation crops like cashew and coconut. The district has 29,831 ha area under cashew with a production of 26, 585 MT and productivity of 890 kg/ ha. Panrutti taluk of Cuddalore stands first in cashew area, production and productivity. Most of the cashew processing industries are located in Panrutti taluk of Cuddalore district.

### **5.6.2 Adoption of cultivation practices / farmers opinion**

- Removal of dry and dead branches , senile/ unproductive trees and trees affected by CSRB . These practices are taken up during May- June after the harvest of the nuts.
- Ploughing the land ( twice or thrice) with a gap of three months depending upon the receipt of rains.
- Application of compost (10-12 t/ha) at the time of first ploughing.
- Application of inorganic manures in the form of either complex fertilizers (majority) or straight fertilizers.
- Common intercrops grown are black gram, groundnut and tapioca.
- Spraying against tea mosquito bug(TMB) with monocrotophos, endosulfan, carbaryl, lambda cyhalothrin, etc., depending on the availability in the market.
- Harvesting is done either with family members (majority) or hired labourers (in case of large farmers) .
- Wherever the irrigation facility is available , flood irrigation is given after fruit set once in ten to fifteen days.

- The variety VRI-2, which has major area under cultivation in the district , is reported to increase the broken kernel proportion while peeling.
- The concept of high density is followed in new plantations especially wherever grafts are supplied by Department of Horticulture through subsidy.
- The yield of cashew gardens ranges between 5 and 10 bags (bags of 60kg each) per acre. The farmers opine that the yield of irrigated gardens are almost double than that of rainfed gardens. However, in the irrigated areas the commercial crops like sugarcane, banana and ground nut etc are competitors for cashew .

### **5.6.3 Training needs of cashew growers.**

- Fertilizers and plant protection chemicals application methods.
- Irrigation techniques .
- Cashew apple processing.
- Soil and water conservation measures.

### **5.6.4 Constraints cashew cultivation**

- Majority plantations are of seedling progenies.
- Lack of supply of quality planting material.
- Yield reduction due pests.
- Lack of irrigation source.
- Nut quality reduction due to summer rains.
- Wide variation in raw nut price.

### **5.6.5 Strategies suggested to improve cashew cultivation**

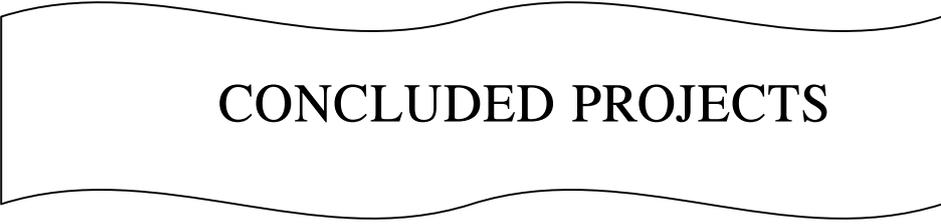
- Introduction and popularization of high yielding cashew varieties .
- Intensive training to cashew growers on plant protection measures, fertilizer application and irrigation.
- Assuring the supply of quality planting material.
- Subsidy for drip irrigation.
- Properly monitoring the genuine nature and quality of the cashew grafts supplied by the private cashew nurseries.

### **5.6.6 Cashew processing in Cuddalore district**

Shelling of raw cashew nuts is being done either after steam boiling or after sun drying the raw cashew nuts for three days. The nuts are commonly shelled by hit method and rarely by hand cum pedal operated shelling machines. In general , all the equipments needed for processing are not available at one place. Some medium scale industries/ exporters collect the peeled kernels from cottage industries and trade them in local or international markets according to the grades of the kernels. Majority of the cottage level industries lack the knowledge about the advantage of steam boiling method .

#### **5.6.6.1 Constraints in cashew processing in Cuddalore district**

- Competing with medium and large scale cashew processors for the procurement of raw nuts and marketing of processed kernels
- Lack of knowledge about advanced process methodology.
- Lack knowledge on value addition to the processed kernels.
- Lack of association of small scale processors for marketing of cashew kernels.



**CONCLUDED PROJECTS**

## 6. CONCLUDED PROJECTS

### 6.1 Influence of fertigation on yield and quality of cashew

Project Leader	Dr. N. Yadukumar
Project Number	Adhoc
Project Duration	2001 – 2004 (Experiments extended upto 2005 as per RAC decision)

#### 6.1.1 Introduction

As water is scarce in cashew growing areas, available water must be efficiently used for crop production and high yields. Drip irrigation economizes water, energy and labour and influences productivity. In drip irrigation and fertilizer application trial, Irrigating at the highest rate of 80 litres per tree once in 4 days through drip system 3-8 years after planting has been shown to be quite beneficial in increasing the yield significantly. The increase in yield was linear with increase in irrigation from 20-80 l/tree once in four days. Linear increase in yield with the increase in fertilizer dose application from 250 g N :62.5 g each of P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O to 7g N:188 g each of P<sub>2</sub>O<sub>5</sub>and K<sub>2</sub>O was also observed

Though the importance of drip irrigation in increasing crop production is realized, efficient use of water and fertilizer through fertigation system is definitely advantageous over other systems of irrigation and fertilizer applications. Work was not done so far in this line previously. It was felt that it would be worthwhile to study its feasibility under normal and high tree density situations. Irrigation with fertilizer applied through drip system would generate information on important variety wise crop response relating to growth behavior, fruit set and finally yield of cashew. The data thus generated will help in assessing the efficacy of fertigation along with soil application of important concentrated organic manures and their effect on yield and quality of nuts. This will help the cashew growers in increasing profit by reducing fertilizer application and irrigation costs and increasing quality of kernels. Hence, an experiment "Influence of fertigation on yield and quality of cashew was laid out at Experimental Station, Shanthigodu during 2001.

#### 6.1 .2 Objectives

- i) Work out optimum quantity of fertilizers to be applied through drip system for yield maximization under normal and high tree density situations.
- ii) Work out water requirement based upon cumulative pan evaporation.
- iii) Assessing effect of fertigation and combinations of fertilizers and organic manuring on two prominent varieties of cashew under normal and high-density situations on yield.
- iv) To assess the quality of nuts produced in terms of proteins, starch, sugars and fat in kernels.

### 6.1.3 Results and Discussion

#### Experiment No.1

Normal tree density (200 trees/ha)

Design : Split plot

#### **Treatments**

Main plots : 12

M-1 : 500 g N, 125 g P<sub>2</sub>O<sub>5</sub>, 125 g K<sub>2</sub>O/plant applied in inorganic form through drip irrigation.

M-2 : 50% of above nutrients applied in inorganic form through drip irrigation and remaining 50% through soil application in the form of neem cake

M-3 : 50% of above nutrients applied in inorganic form through drip irrigation and remaining 50% through soil application in the form of castor cake

M-4 : 750 g N, 188 g P<sub>2</sub>O<sub>5</sub>, 188 g K<sub>2</sub>O/plant applied in inorganic form through drip irrigation.

M-5 : 50% above nutrients applied in inorganic form through drip irrigation and remaining 50% through soil application in the form of neem cake

M-6 : 50% of above nutrients applied in inorganic form through drip irrigation and remaining 50% through soil application in the form of castor cake.

M-7 : 500 g N, 125 g P<sub>2</sub>O<sub>5</sub>, 125 g K<sub>2</sub>O/plant soil application in inorganic form and separately drip irrigated.

M-8 : 750 g N, 188 g P<sub>2</sub>O<sub>5</sub>, 188 g K<sub>2</sub>O/plant soil application in inorganic form and separately drip irrigated.

M-9 and M-10 : 50% of M-7 through inorganic form (soil application) and 50% through organic both soil application (neem and castor cake respectively) and separately drip irrigated.

M-11 and M-12 : 50% of M-8 through inorganic form (soil application) and 50% through organic (neem and castor cakes respectively) and separately drip irrigated.

M-13 : Control plot receiving no irrigation and fertilizers

Sub plots : 3

I-1 : Drip irrigation-20% of CPE (Cumulative Pan Evaporation)

I-2 : Drip irrigation-40% of CPE

I-3 : Drip irrigation-60% of CPE

Variety used : 10 years old VRI-1 planted at 7m x 7m distance

## **Experiment No.2**

High tree density (625/ha)

Design : Split plot

### **Treatments**

Main plots : 12

M-1 : 250 g N, 62.5 g P<sub>2</sub>O<sub>5</sub>, 62.5 g K<sub>2</sub>O/plant applied in inorganic form through drip irrigation.

M-2 : 50% of above nutrients applied in inorganic form through drip irrigation and remaining 50% through soil application in the form of neem cake

M-3 : 50% of above nutrients applied in inorganic form through drip irrigation and remaining 50% through soil application in the form of castor cake

M-4 : 500 g N, 125 g P<sub>2</sub>O<sub>5</sub>, 125 g K<sub>2</sub>O/plant applied in inorganic form through drip irrigation.

M-5 : 50% above nutrients applied in inorganic form through drip irrigation and remaining 50% through soil application in the form of neem cake

M-6 : 50% of above nutrients applied in inorganic form through drip irrigation and remaining 50% through soil application in the form of castor cake.

M-7 : 250 g N, 62.5 g P<sub>2</sub>O<sub>5</sub>, 62.5 g K<sub>2</sub>O/plant soil application in inorganic form and separately drip irrigated

M-8 : 500 g N, 125 g P<sub>2</sub>O<sub>5</sub>, 125 g K<sub>2</sub>O/plant soil application in inorganic form and separately drip irrigated

M-9 and M-10 : 50% of M-7 through inorganic (soil application) and 50% through organic both soil application (neem and castor cake respectively) and separately drip irrigated.

M-11 and M-12 : 50% of M-8 through inorganic (soil application) and 50% through organic (neem and castor cakes respectively) and separately drip irrigated.

M13 : No irrigation and no manure-control

Sub plots : 3

I-1 : Drip irrigation-20% of CPE (Cumulative Pan Evaporation)

I-2 : Drip irrigation-40% of CPE

I-3 : Drip irrigation-60% of CPE

Variety used : Bhaskara grafts (4 years old graft planted at 4m x 4m spacing)

In normal planting density drip irrigation was given at the rate of 12 l/tree/day from December to January (Daily open pan water evaporation is 5mm) and 20 l/tree/day from February to March (Daily open pan water evaporation is 6.5mm) to meet 20 of the evaporative demand. Like wise for higher irrigations it is 24 l/tree/day from December to January and 38 l/tree/day from February to March to meet 40 % of the evaporative demand. Like wise for still higher irrigations it is 36 litres per tree per day from December to January and 58 l/tree/day from February to March to meet 60 % of the evaporative demand.

In high density planting system drip irrigation was given at the rate of 7 l/tree/day from December to January (Daily open pan water evaporation is 5mm) and 9 litres from February to March (Daily open pan water evaporation is 6.5mm) to meet 20 % of the evaporative demand. Like wise for higher irrigations it is 14 l/tree/day from December to January and 18 l/tree/day from February to March to meet 40 % of the evaporative demand. Accordingly, for still higher irrigations it is 21 l/tree/day from December and January and 27 l/tree/day from February to March to meet 60 % of the evaporative demand.

The above quantity of irrigation water given through drip was calculated by taking into consideration the effective area occupied by the trees in two different planting situations. The effective canopy coverage for the normal density planting system was taken as 12.56 Sq M/tree and for high density planting system it was taken as 7 Sq M. The evaporative demand in December as well as in March at the rate of 5mm and 6.5mm daily respectively works out to be 61 l and 82 l /tree/day in normal density planting system and it is 35 and 46 l /tree/day in high density planting system.

Under normal density planting situations to meet 20 per cent of evaporative demand four drippers of 2 l/h discharge rate were fitted at four equidistant points 1M away from the stem at the base. Like wise to meet 40 and 60 % of CPE four drippers each of 4 l discharge rate and six drippers each of 4 l discharge rate respectively were fixed. Each time the drip irrigation was given for 1.5 h during December and January (CPE is 5mm per day) and 2 h in February and March (CPE is 6.5mm per day). Under high density planting situations to meet 20 per cent of evaporative demand two drippers of 2 l/h discharge rate were fitted at two equidistant points 1M away from the base of the tree. Like wise to meet 40 and 60 % of CPE two drippers 4 l discharge rate as one set and three drippers of 4 l discharge rate as another set were fixed. Each time the drip irrigation was given for 1 hour 45 min during December and January and 2 h and 15 minutes in February and March.

The fertilizers like urea, diammonium phosphate and muriate of potash in the ratio of 1.76 kg (Urea): 0.55 kg (Diammonium phosphate): 0.36 kg (Muriate of potash) respectively were dissolved in water and applied to 6 plants through drip irrigation system per month. Like this 5 doses were given for one season. For other fertilizer doses treatments the mixture of fertilizers was prepared accordingly and applied. Each split dose was is given once in each month starting from October to December and from January onwards the monthly-allotted dosage was further split into four doses and given once in a week up to February. Any phosphatic fertilizers available (SSP or Rock phosphate) in the market cannot be given through drip irrigation system due to precipitation in the pipeline resulting blocking of drippers. Out of 46% P<sub>2</sub>O<sub>5</sub> content in diammonium phosphate 41% is water-soluble and hence the fertilizer is dissolved in

water making fertilizer content to 1.5% and the solution is allowed to settle and supernatant liquid is decanted and applied through drip system.

Organic manures were applied as per the treatments soon after the heavy monsoon was over (September) in pits where fertigation was done around the basin of the plant. Irrespective of the treatments all the plants were provided with thick mulch at the base of the plant to suppress weed growth, reduce soil temperature during peak summer season and to reduce evaporation. All the soil conservation techniques like terracing and opening catch pit in addition to mulching was taken up common to all plants. Application of lime at the rate of 2 kg/plant/year in experiment 1 and 0.5 kg/plant/year in experiment 2 were done with the on set of each monsoon season.

In experiment 1 fertilizer treatments like 750g N, 188g P<sub>2</sub>O<sub>5</sub> and 188g K<sub>2</sub>O/tree (150 kg N : 37.6 kg P<sub>2</sub>O<sub>5</sub> : 37.6 kg K<sub>2</sub>O/ha) and 500g N, 125g P<sub>2</sub>O<sub>5</sub> and 125g K<sub>2</sub>O/tree (100 kg N : 25 kg P<sub>2</sub>O<sub>5</sub> : 25 kg K<sub>2</sub>O/ha) were included for 11year old cashew trees (VRI-1) and in experiment 2 (high density planting system) the fertilizer dosage included were 500g N, 125g P<sub>2</sub>O<sub>5</sub> and 125g K<sub>2</sub>O/tree (312.5 kg N : 78.12 kg P<sub>2</sub>O<sub>5</sub> : 78.12 kg K<sub>2</sub>O/ha) and 250g N, 62.5g P<sub>2</sub>O<sub>5</sub> and 62.5g K<sub>2</sub>O/plant (156.66 kg N : 39.06 kg P<sub>2</sub>O<sub>5</sub> : 39.06 kg K<sub>2</sub>O/ha) were included for five years old cashew trees. This was done due to high plant population (625 trees/ha) per unit area. Fertilizers applied in high density planting system plot was proposed to be equal to the plot where normal plant population (200 trees/ha) was to be maintained as one treatment and one level above this was also included presuming better response for higher dose in high density planting system also. In experiment 2 the fertilizer dosage fixed for different treatments was proposed to be applied 2/3<sup>rd</sup> in second year and full dose from 3<sup>rd</sup> year onwards.

## 6.1.4 Conclusions

### 6.1.4.1 Experiment 1: Normal density planting system (200 trees/ha-12 years old cashew trees of VRI-1 variety)

- An increase of 100 % and 226 % in yield was observed in treatment receiving half of recommended dose of NPK in inorganic form (recommended dose -500 g N, 125 g each of P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O/tree/year) of nutrients through fertigation and balance half applied in organic form through castor cake as compared to the above dose through soil and separately irrigated and absolute control (without manure and irrigation) respectively indicating better nutrient use efficiency.
- The irrigation at the rate of 60 % of Cumulative Pan Evaporation (CPE) resulted in significant increase in yield compared to 20 and 40 % CPE.
- Highest profit of Rs.27,294/ha (with B:C Ratio of 3.71) was achieved in plot receiving half of recommended dose of nutrients through fertigation and balance half applied in the form of castor cake to soil, while the profit was Rs. 8,995 when the NPK dose was given to soil.
- Protein content of defatted kernel flour was high (38.3%) in trees receiving 50% of recommended doses of NPK in inorganic form through fertigation and the balance 50% in the form of castor cake applied to soil, while protein content observed in treatments receiving recommended doses of NPK in inorganic form through fertigation and absolute control was lower (32.08% and 32.35% respectively). Starch and sugars of kernels did not vary due to fertigation treatments

#### **6.1.4.2 Experiment 2: High density planting system (625 trees/ha- 5 year old trees of Bhaskara variety)**

- An increase of 15 % and 74 % in yield was observed in treatment receiving half of lower dose of NPK in inorganic form (lower dose-250 g N, 63 g each of P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O/tree/year) of nutrients through fertigation and balance half applied in organic form through castor cake as compared to the above dose applied to soil and separately irrigated and absolute control (without manure and irrigation) respectively. With this, the total nutrients to be applied can be reduced to half when given through fertigation system indicating better nutrient use efficiency.
- The irrigation at the rate of 20 %, 40 % and 60 % of Cumulative Pan Evaporation (CPE) did not result any change in the yield and hence irrigation at the rate of 20 % of CPE is the best and also water saving.
- Highest profit Rs. 48,379/ha with B: C ratio of 3.39 was achieved in plot receiving half of lower dose of nutrients through fertigation and balance half applied in the form of castor cake. While profit was Rs. 39,820 and Rs. 33,086 when same and double NPK dose was given to soil
- Protein content of defatted kernel flour was high (40.69 %) in trees receiving half of lower dose of nutrients through fertigation and balance in organic form through castor cake to soil compared to application of same quantity of nutrients to soil (36.63%). Lowest protein (33.23 %) concentration was observed in absolute control treatment (trees receiving neither irrigation nor manure)

#### **6.1.4.3 Results of practical utility**

The results obtained will help farmers for maximizing yield and profit in cashew by fertigation, combined with soil application of organic manure (castor cake). By adopting these methods farmers can get 100% and 226% increase in yield under normal density planting situations and 15% and 74% under high density planting system compared to treatment of application of same quantity of nutrients to soil and treatment with no application of manure and irrigation respectively.

## 6.2 Canopy management studies in cashew

Project Leader : Dr.M. Gangadhara Nayak (1992-1996 and 1999-2006)  
: Dr. KRM Swamy (1996-1999)  
Project Associates : Dr. N. Yadukumar (1998-2001)  
: Dr. T.N. Raviprasad (2002-2004)  
Project Number : 2.3  
Project Duration : 1992 - 2006

### 6.2.1 Introduction

Pruning of the dead wood in older plantations alone helps in increasing the nut yield upto 30-40 per cent. Results from earlier studies on time and severity of pruning revealed that the leader shoot pruning helps in stabilizing the yield in older plantations with problem of decline in yield.

In other tree crops like apple, pruning helps in inducing dwarfing and thereby better size and shape to the canopy and same has been recommended in high density planting to restrict the tree size and to improve the quality of the produce. Pruning also helped in changing the pattern of branching and flushing in several other crops like grapes, apple etc. In view to understand the effect of pruning on different branching flowering, growth and yield the study was initiated with the following objectives:

### 6.2.2 Objectives

- i) To study the effect of pruning on branching behaviour of different cashew varieties.
- ii) To study the effect of pruning on flowering on cashew.
- iii) To study the effect of pruning on dwarfing and canopy containment in cashew.
- iv) To study the effect of pruning on yield and stabilization of yield propagated cashew plants.

### 6.2.3 Treatments

EeP<sub>1</sub> E1P<sub>1</sub> leP<sub>1</sub> l1P<sub>1</sub>  
EeP<sub>2</sub> E1P<sub>2</sub> leP<sub>2</sub> l1P<sub>2</sub>  
EeP<sub>3</sub> E1P<sub>3</sub> leP<sub>3</sub> l1P<sub>3</sub>  
EeP<sub>4</sub> E1P<sub>4</sub> leP<sub>4</sub> l1P<sub>4</sub>

## Varieties selected

- i) Branching → Extensive (E) → Intensive (1)
- ii) Flowering → Early (e) → Later (1)
- iii) Pruning → No pruning (P<sub>1</sub>) → Yearly pruning (P<sub>2</sub>)  
Alternate year pruning (P<sub>3</sub>) → Shape pruning (P<sub>4</sub>)

Extensive branching and early flowering type	VTH 30/4
Extensive branching and late flowering type	NRCC Sel-1
Extensive branching and early flowering	VRI-1
Intensive branching and late flowering	Ullal-1

This experiment was considered as 2x2x4 factorial experiment in RCBD design with three replications. Plants were planted at a spacing of 8m x 8m.

Growth, parameters such as height of plant, spread of plant, girth at collar region, no. of laterals per unit area, no. of leaves per unit area, leaf area, light interception, net photosynthesis, nut yield were recorded.

After 10 years when the canopies got over crowded the trees pruned severely by heading back the canopies to redevelop the canopies. The trees which were not pruned from the beginning (control) were pruned and left as such without pruning.

Pruning treatments were imposed every year during the period between second first night of July to fort night of August. Once in 2 years a cycle of pruning was completed. The leaf biomass removed by means of pruning was similar every year. In the early part it ranged from 2-3 kg per plant and in later stages it gradually increased over the years. The alternate year pruning had significantly higher biomass was removed once in 2 years compared to yearly pruned plants.

With an objective of standardizing a optimum canopy shape from the beginning of the orchard life various tree training systems such as central leader, modified leader, open centre vase system and training grafts to bush were tried.

The Ullal-3 plants which were planted during the year 1999 were utilized for the study. The plants were planted at a spacing of 5m x 5m. Four plants in each row were trained to 4 different training system mentioned above. Every year during the period between May - June the plants were trained to above said canopy shapes. Observations were recorded on yield. This trial was mainly conducted to assess whether various canopy shapes to cashew trees be forced or not.

## 6.2.4 Results and discussion

### 6.2.4.1 Effect of leader shoot pruning on plant growth

During the period of plant growth, every year observations on various growth parameters, leaf and nutrient status, light interception, fruit bearing pattern in different layers of canopy were recorded.

The plant growth was vigorous in all the four varieties under study. Among different varieties studied NRCC Sel-1 had more vigorous growth with respect to height, spread, number of laterals per unit area, and length of the flowering laterals (Table 6.1). Variation due to varieties was non significant for plant height, trunk girth, canopy spread

and leaf area. The different pruning treatments did not change the growth pattern in different varieties during early part of orchard life.

Number of flowering laterals were drastically reduced in yearly pruned and alternate year pruned trees compared to shape pruned and unpruned trees while the number of non-flowering laterals were more in yearly pruned and alternate year pruned trees. Length of flowering and non flowering laterals was considerably reduced in yearly pruned trees. The leaf biomass dropped was upto the tune of 10.48 kg annually in NRCC Sel-1 trees and the pruning treatments did not influence the quantity of leaf fall.

Yearly leader shoot pruning induced more flowering in varieties like VRI-1 and NRCC Sel-1 while in other two varieties had negative effect. Number of leaves were more in yearly pruned trees and the leaf area was higher though the biomass removal was higher in those plants. The length of lateral shoot in yearly pruned was reduced due to leader shoot pruning. Probably the leader shoot pruning due to heading back must have induced the lateral growth, as a result of which the growth of lateral shoots must have been stunted (Table 6.2).

#### **6.2.4.2 Effect of leader shoot pruning on leaf area**

Leaf area was maximum in NRCC Sel-1 particularly, in the trees which were pruned every year and alternate year. Only in varieties like VTH 30/4 and VRI-1 the yearly pruning reduced the leaf area when compared to shape pruned trees or unpruned trees (Fig. 6.1). In general it is observed that extensive branching types when pruned induced more number of leaves and thereby more leaf area while in intensive branching types the general branching even otherwise will be higher and as a result the additional leaf area could not be achieved in yearly pruned trees.

#### **6.2.4.3 Effect of pruning on soil and leaf nutrient status**

In the early stage of orchard life (after 6 year onward) for 3 consequent years the leaf and soil nutrient status of pruned and unpruned plants was studied and it indicated that soil and nutrient status did not vary much with respect to various pruning treatments (Table 6.3).

Soil fertility status assessed through soil analysis revealed that the soil of the plot is medium in nitrogen and potassium and low in phosphorous content as per soil fertility status classification.

#### **6.2.4.4 Effect of pruning on light interception**

On an average only about 10 per cent of light was allowed to reach the ground by plants of four different varieties which were pruned. About 90 per cent of the incident light is intercepted by crop canopy of different varieties. Maximum light (69.23 to 93.85) was intercepted by top portion of canopy and 0 to 16.0 per cent by mid portion of canopy while the bottom (lower) portion of canopy intercepted 2.68 to 14.74 per cent of the light. Top portion of the canopy of pruned trees intercepted more light (86 – 87 per cent) compared to unpruned trees (80.7 per cent) (Fig. 6.2 and 6.3). The higher light interception could be attributed to the higher leaf area in the yearly pruned trees of Ullal-1, NRCC Sel-1 and VRI-1 compared to unpruned trees. Pruning drastically reduced the leaf area in VTH 30/4 variety.

#### **6.2.4.5 Effect of pruning on yield**

##### **Fruit bearing pattern in low, middle and top portion of canopy**

The mean yield for four varieties estimated at bottom (low), middle and top portion of tree canopies revealed that the middle layer branched yielded 49.52 per cent and top portion of canopy yielded 32.9 per cent while bottom layer branches yielded 17.58 per cent (Table 6.4). Even if the plants were pruned yearly or once in two years the bearing pattern was similar in top, middle and bottom level branches.

#### **6.2.4.6 Estimated yield during the year 2001-02**

Estimated yield of various pruned trees by computing the yield attributes viz., extent of flowering, number of flower panicles per m<sup>2</sup>, canopy area number of nuts/panicle and weight of nut indicated that leader shoot pruning has no significant influence on yield. The yield in unpruned trees is either higher or similar to that of yield of pruned trees except in VTH 30/4 variety wherein yearly pruned tree had higher yield (Table 6.5). In NRCC Sel-1 and VRI-1 varieties, pruning had detrimental effect on bearing during this season as per the yield estimation. The actual realized yield was near 80 per cent of the estimated yield during the fruiting season 2002.

#### **6.2.4.7 Effect of leader shoot pruning on yield**

In the early stage of plantations the yield in general was low. Severe pest (TMB) damage in this plot also were noticed in certain years which affected the crop yield. The cumulative yield of first 3 years revealed that pruned plants of VRI-1 and Ullal-1 had adverse affect on yield while VTH 30/4 and NRCC Sel-1 pruning helps in enhancing yield performance. Thereafter the yield performance of all the varieties was increased (Table 6.6 & 6.7). The yield stabilization was observed after 7-8 years after planting. The pruning treatment did not significantly affect yield performance of different varieties. The yield in all the varieties as well as the trees of different pruning treatments remained similar. The weight of the nut also recorded over the years which did not show any significant difference among different varieties (Table 6.9). Weight of the nut among pruning treatments though varied the difference was negligible.

The unpruned plants (check) produced significantly more nut yield (4.5 kg cum. yield/plant), followed by shape pruning, alternate year pruning and yearly pruning. Multivariate as well as univariate tests conducted with the yield data revealed that there was no significant difference with the incremental yield in different treatments. Weight of the apple was also reduced in yearly pruned plants.

#### **6.2.4.8 Effect of decrowning by limb pruning on cashew**

In the initial years growth was not affected by various pruning treatments. Trees of all the varieties irrespective of treatments occupied allotted space of 8m x 8m within 8-9 years. The lower branches and twigs slowly started drying due to non availability of sufficient sun light. Many of the tree canopies looked exhausted at that moment, it was felt to go for severe pruning of the trees during 2003 June-July heading back was done by pruning away the major branches.

The beheaded stumps of trees putforth new sprouts from dormant buds and new canopies were formed. In varieties like VTH 30/4 and NRCC Sel-1, pruned trees mostly remained vegetative in first fruiting season after pruning and in NRCC Sel-1, the trend

continued in second season also as more than 50 per cent flushes remained vegetative. In varieties like VRI-1 and Ullal-1 more than 60 per cent of new flushes flowered and fruited though the yield was less than control in the first season after pruning while, in the second season yield was significantly superior over control (Table 6.10). The flowering and fruiting was delayed in pruned plants by 20-25 days in all the varieties upto second season of fruiting.

In the third fruiting season after beheading, the trees behaved on par with unpruned trees in flowering and fruiting time. In pruned trees almost all the new lateral shoots flowered. The yield in pruned plants was significantly superior in all the four varieties (Table 6.11). Different pruning treatments imposed such as yearly pruning, pruning once in two years and shape pruning for the maintenance of the canopy did not vary in yield performance.

#### **6.2.4.9 Canopy architecturing**

In the observational trial on canopy architecturing, training of grafts for the development of suitable canopy shapes indicated that various canopy shapes such as central leader, modified leader, open centre system or bush type can be induced. Pruning the grafts of variety Ullal-3 to bush shape by removing the annual growth immediately after the harvest produced normal flowering and fruiting till fifth year after planting but in the sixth year the bush pruned trees were mostly vegetative with negligible yield (Table 6.12). It was observed that after 3 years by training systems other than bush pruning system plants cannot be maintained at closer spacing (5m x 5m) as canopies get over crowded as a result yield decline begins. In bush pruned plants of Ullal-3 though yield reduction noticed the results were encouraging. A suitable genotypes (varieties) needs to be identified for such pruning system.

#### **6.2.5 Conclusions**

- Pruning helps in shaping the canopy in early years, however the growth and yield pattern could not be changed in early part of orchard life.
- Leader shoot pruning every year has adverse effect on growth and fruit bearing. It induces more vegetative growth and more of non flowering shoots. Continuous pruning also makes plants more vulnerable for tea mosquito bug attack.
- Maintenance of canopy shape and exposing to maximum sunlight by shape pruning helps in keeping productive and better performance than yearly or alternate year leader shoot pruning.
- When plants canopies get over crowded and when the canopy gets exhausted canopy can be headed back by limb pruning for rejuvenation and redevelopment.
- Limb pruning should be done with enough care to prevent the attack of stem and root borer.
- Young grafts should be shaped in the initial years as desired so as to maintain productive in formative years.
- Training grafts of suitable variety to bush shape appears to be encouraging for high density orchards.

**Table 6.1: Effect of leader shoot pruning on growth of different cashew varieties**

Treatment	Plant height (m)	Canopy spread (m <sup>2</sup> )	Number of laterals / m <sup>2</sup>		Length of laterals (cm)		Total leaf biomass dropped (kg)	Leaf biomass removed by means of pruning (kg)
			Flowering	Non-flowering	Flowering	Non-flowering		
<b>A. Varieties</b>								
VRI-1	4.53	6.26	6.83	14.75	33.67	16.58	7.92	1.51
Ullal-1	5.48	6.50	1.42	14.42	34.75	18.42	7.46	1.09
VTH 30/4	4.34	6.35	1.5	13.67	34.92	17.17	7.53	1.11
NRCC Sel-1	5.71	6.75	12.08	1292	35.17	22.17	10.48	1.96
CD (0.05)	NS	NS	1.13	NS	NS	3.21	NS	NS
<b>B. Pruning</b>								
No pruning	5.14	7.00	16.08	13.42	36.58	22.33	8.44	0.00
Yearly pruning	5.01	6.55	12.00	15.58	31.50	15.58	833	1.58
Alternate year pruning	5.01	3.35	12.33	14.75	3.83	18.17	8.27	2.25
Shape pruning	4.91	6.48	14.50	12.00	33.58	18.42	8.34	1.74
CD for B	NS	NS	NS	3.35	5.15	3.01	NS	0.45
CD for AB	NS	NS	NS	NS	NS	6.02	NS	0.89

**Table 6.2: Growth and flowering behaviour of different cashew varieties as affected by pruning.**

Variety	Treatments	Flowering intensity per m <sup>2</sup> (%)	No. of leaves / lateral	Length of lateral (cm)
VRI-1 (Intensive, Early)	C1	32.1	11.5	28.0
	C2	36.0	14.0	26.7
	C3	30.2	13.1	23.4
	C4	31.2	11.2	25.5
Ullal-1 Intensive, Late)	C1	35.6	9.8	27.8
	C2	29.5	11.7	23.8
	C3	31.3	10.5	2.3
	C4	26.4	11.5	23.8
VTH 30/4 (Extensive, Early)	C1	30.8	10.3	25.3
	C2	29.5	11.4	23.8
	C3	31.1	11.3	24.1
	C4	24.5	10.3	24.9
Selection-1 (Extensive, Late)	C1	25.8	11.5	33.8
	C2	34.7	14.2	31.5
	C3	25.9	12.8	28.4
	C4	28.7	1.8	30.2
CD (Var)		NS	0.95	1.10
SEM (Var)		-	0.33	0.38
CD (Prun.)		3.55	0.95	1.10
SEM (Prun.)		1.23	0.33	0.38

**Table 6.3: Fertility status of plot and leaf nutrient contents.**

Treatment	Soil organic matter content (%)			Soil N content (kg/ha)			Soil P <sub>2</sub> O <sub>5</sub> content			Soil K <sub>2</sub> O content			Leaf nutrient content (%)		
	0-30 cm	30-60 cm	60-90 cm	0-30 cm	30-60 cm	60-90 cm	0-30 cm	30-60 cm	60-90 cm	0-30 cm	30-60cm	60-90cm	N	P	K
<b>A. Varieties</b>															
VRI-1	4.88	3.95	2.65	318.53	257.65	172.40	19.78	10.38	4.69	320.71	237.32	168.14	2.06	0.13	0.49
Ullal-1	5.12	3.61	2.36	333.52	235.09	152.91	15.46	8.44	3.21	289.94	185.33	231.17	1.60	0.10	0.39
VTH 30/4	4.95	3.85	2.42	335.79	251.04	157.21	25.16	14.41	5.89	396.82	293.61	203.71	1.60	0.13	0.38
NRCC Sel-1	5.00	3.77	2.59	319.15	245.66	189.91	28.30	15.09	10.00	275.00	202.38	176.85	1.67	0.12	0.39
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
<b>B. Pruning</b>															
No pruning	4.88	3.57	2.01	311.48	232.80	151.47	29.94	16.58	8.66	377.13	253.34	202.07	1.93	0.14	0.39
Yearly pruning	4.88	3.45	2.46	330.84	224.73	160.25	21.88	12.92	6.79	337.98	245.64	203.42	1.96	0.12	0.40
Alternate year pruning	4.91	3.68	2.59	320.22	240.36	168.91	15.52	7.02	4.16	232.98	185.58	199.04	1.48	0.11	0.42
Shape pruning	5.29	4.47	2.94	344.45	291.56	191.81	21.35	11.80	4.18	335.10	234.08	175.38	1.54	0.12	0.45
CD B	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD (A x B) 0.05	1.45	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	168.78	0.91	NS	NS

**Table 6.4: Fruiting pattern at low, middle and top portion of canopy**

A. Varieties	Estimated yield (kg)			
	Lower portion of canopy	Middle portion of canopy	Top portion of canopy	Total Yield (kg/tree)
VRI-1	0.90 (15.52)	3.10 (53.45)	1.80 (31.05)	5.80
Ullal-1	1.86 (18.27)	4.34 (42.93)	3.98 (30.09)	10.18
VTH 30/4	1.09 (16.87)	3.29 (50.92)	2.08 (32.19)	6.46
NRCC Sel-1	1.26 (19.69)	3.27 (51.09)	1.87 (29.22)	6.40
Mean for A	1.28 (17.58)	3.50 (49.52)	2.43 (32.90)	
CD for A (P=0.05)	0.43 (NS)	0.92	0.75	
<b>B. Pruning</b>				
No pruning	1.62 (20.12)	3.72 (46.21)	2.71 (33.66)	8.05
Yearly pruning	1.25 (18.04)	3.14 (45.31)	2.54 (36.65)	6.93
Alternate year pruning	0.98 (14.38)	3.35 (50.69)	2.28 (34.49)	6.61
Shape pruning	1.27 (17.45)	3.80 (52.20)	2.21 (30.36)	7.28
Mean for B	1.28 (17.45)	3.50 (48.60)	2.43 (33.79)	
CD for B (P=0.05)	NS	NS	NS	
CD for A x B (P=0.05)	NS	NS	1.50	

**Table 6.5: Effect of pruning yield attributes**

Variety	Treatment	Extent of flowering (%)	No. of panicles/m <sup>2</sup>	Canopy area (m <sup>2</sup> )	No. of nuts per panicle	Estimated yield / tree (kg)
VRI-1	P <sub>1</sub>	95	19.0	21	3	7.35
	P <sub>2</sub>	89	16.0	14	3	5.16
	P <sub>3</sub>	94	18.0	18	4	7.50
	P <sub>4</sub>	92	16.0	13	3	3.80
Ullal-1	P <sub>1</sub>	86	15.	16	8	10.66
	P <sub>2</sub>	91	16.0	12	8	10.08
	P <sub>3</sub>	82	1.0	15	8	0.68
	P <sub>4</sub>	83	13.0	16	8	10.23
VTH 30/4	P <sub>1</sub>	90	14.0	16	4	5.58
	P <sub>2</sub>	88	13.0	26	4	8.80
	P <sub>3</sub>	77	11.0	12	4	3.62
	P <sub>4</sub>	76	11.0	17	4	6.00
NRCC Sel-1	P <sub>1</sub>	74	9.8	25	4	6.81
	P <sub>2</sub>	60	9.6	13	4	4.02
	P <sub>3</sub>	45	9.3	13	3	2.63
	P <sub>4</sub>	56	8.2	22	4	8.32

**Table 6.6: Effect of pruning on yield of cashew**

Treatment	Cumulative yield of first 4 harvests	No. of nuts/panicle (nut retention)	Weight of nut (g)	Weight of apple (g)
<b>A. Varieties</b>				
VRI-1	8.1	5.00	6.16	61.27
Ulla-1	8.0	10.50	6.98	56.00
VTH 30/4	8.4	6.42	8.93	92.50
NRCC Sel-1	8.3	6.50	8.63	84.67
CD (0.05)	NS	3.11	0.20	3.06
<b>B. Pruning</b>				
No pruning	8.3	7.75	7.68	73.60
Yearly pruning	7.9	4.58	7.56	68.42
Alternate year pruning	7.9	7.33	7.68	77.17
Shape pruning	8.7	8.75	7.77	75.25
CD for B	0.57	1.45	0.10	2.68
CD for AB	NS	2.90	NS	5.37

**Table 6.7: Cumulative yield/plant (kg) of initial 3 harvest**

Variety	No pruning	Yearly pruning	Alternate year pruning	Shape pruning	Mean of varieties
VRI-1	5.5	4.0	4.8	4.7	4.7
Ulla-1	5.0	4.0	3.7	4.6	4.3
VTH 30/4	3.9	4.2	3.9	4.3	4.1
Sel-1	3.9	2.9	3.9	4.1	3.7
Mean of pruning levels	4.6	3.8	4.0	4.4	

CD for variety : NS

CD for pruning : 0.057

CD for variety x pruning : NS

**Table 6.8: Effect of leader shoot pruning on cumulative yield of cashew (Kg/plant)**

	1999-2000	2000-01	2001-02	2002-03
<b>A. Varieties</b>				
VRI-1	8.1	13.52	16.50	21.84
Ulla-1	8.0	14.42	18.70	23.43
VTH 30/4	8.4	14.78	1.77	23.97
NRCC Sel-1	8.3	14.37	17.76	22.46
CD for A (P=0.05)	NS	NS	NS	NS
<b>B. Pruning</b>				
No pruning	8.3	14.60	18.22	23.83
Yearly pruning	7.9	13.68	17.36	22.14
Alternate year pruning	7.9	13.88	17.25	22.05
Shape pruning	8.7	14.91	18.89	23.49
Mean for B	0.57	NS	NS	NS
CD for B (P=0.05)	NS	NS	NS	NS

**Table 6.9: Effect of pruning on weight of nut (g)**

Treatment	1999-2000	2000-2001	2001-2002	2002-2003
<b>A. Varieties</b>				
VRI-1	6.16	6.16	6.13	6.27
Ullal-1	6.98	6.98	6.98	7.05
VTH 30/4	8.93	8.93	8.93	8.78
NRCC Sel-1	8.63	8.63	8.64	8.34
CD for A (P=0.05)	0.20	-	0.68	0.22
<b>B. Pruning</b>				
No pruning	7.68	7.68	7.72	7.65
Yearly pruning	7.56	7.56	7.55	7.61
Alternate year pruning	7.68	7.68	7.68	7.60
Shape pruning	7.77	7.77	7.33	7.59
CD for B (P=0.05)	0.10	0.10	0.68	NS
CD for A x B (P=0.05)	NS	NS	0.13	NS

**Table 6.10: Effect of limb pruning on growing behaviour of plants**

Treatment	Biomass removed	Height of plant (M)	Canopy spread (M <sup>2</sup> )	No. of flushes / (M <sup>2</sup> )	No. of flowering laterals/ (M <sup>2</sup> )
<b>A: Variety</b>					
VRI-1	98.53	4.42	4.98	25.95	14.1
Ullal-1	111.0	4.37	4.30	28.75	20.50
VTH 30/4	119.67	4.44	5.04	21.25	5.58
NRCC Sel-1	156.57	4.86	4.85	24.17	2.50
CD for A (P=0.05)	32.69	0.27	NS	2.73	1.62
<b>B: Pruning</b>					
No pruning	0.001	6.07	8.00	18.33	13.92
Yearly pruning	66.78	4.07	3.97	25.58	9.67
Alternate year pruning	165.96	3.86	3.76	27.58	9.92
Shape pruning	153.52	4.09	3.86	28.58	9.25
Mean	121.57	4.2	4.90	25.02	10.69
CD for B (P=0.05)	32.69	0.27	0.26	2.73	1.62
CD for A x B (P=0.05)	NS	0.54	0.53	NS	3.23

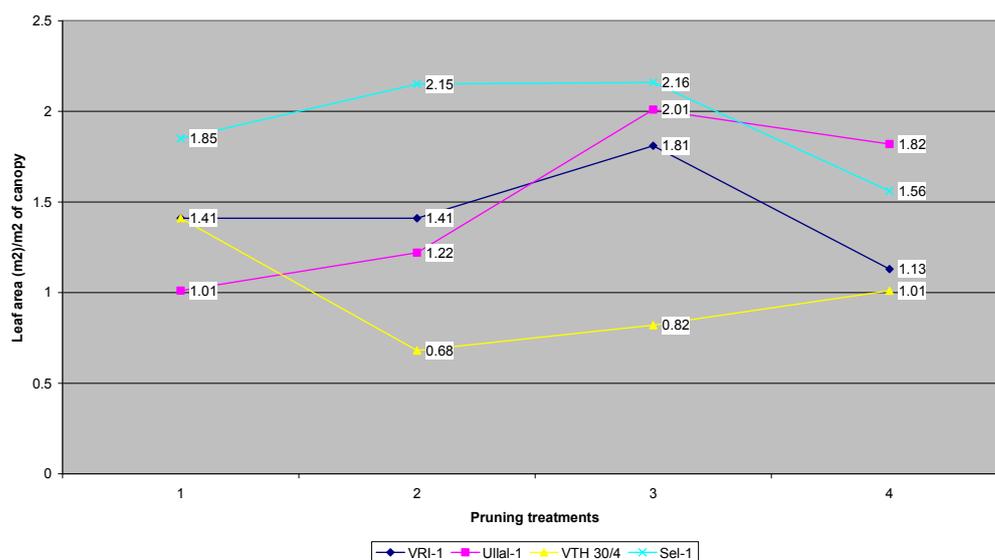
**Table 6.11: Effect of limb pruning on nut yield and nut and apple weight**

Treatment	Yield per tree (kg)			Nut weight (g)	Apple weight (g)
	2003-2004	2004-2005	2005-2006		
<b>A. Varieties</b>					
VRI-1	1.62	3.19	8.01	6.39	62.24
Ullal-1	2.95	4.42	8.84	7.25	55.54
VTH 30/4	1.18	4.61	9.30	8.59	92.87
NRCC Sel-1	0.72	1.23	8.10	8.25	85.73
Mean				0.37	1.14
CD for A (P=0.05)	0.44	0.45	0.89		
<b>B. Pruning</b>					
No pruning	3.25	3.01	5.59	7.67	74.14
Yearly pruning	2.00	3.71	9.27	7.61	73.81
Alternate year pruning	0.97	3.76	9.76	7.68	74.56
Shape pruning	1.05	3.55	9.63	7.52	73.88
Mean				7.62	74.09
CD for B (P=0.05)	0.44	0.45	0.89	NS	NS
CD for A x B (P=0.05)	0.88	0.90	1.80	NS	NS

**Table 6.12: Growth and yield of 5 year old shape pruned plants**

Training systems	Height (M)	Canopy spread (M <sup>2</sup> )	Yield/plant (Kg)
Central leader	3.9	5 x 5	2.9
Modified leader	3.5	5 x 5	3.4
Open centre	3.4	5 x 5	3.8
Bush shape	1.5	2 x 2	2.7
Control	3.9	5 x 5	3.1

**Fig.1: Influence of pruning on leaf area**



**Fig. 6.1: Influence of pruning on leaf area**

Fig.2: Light interception in different cashew varieties

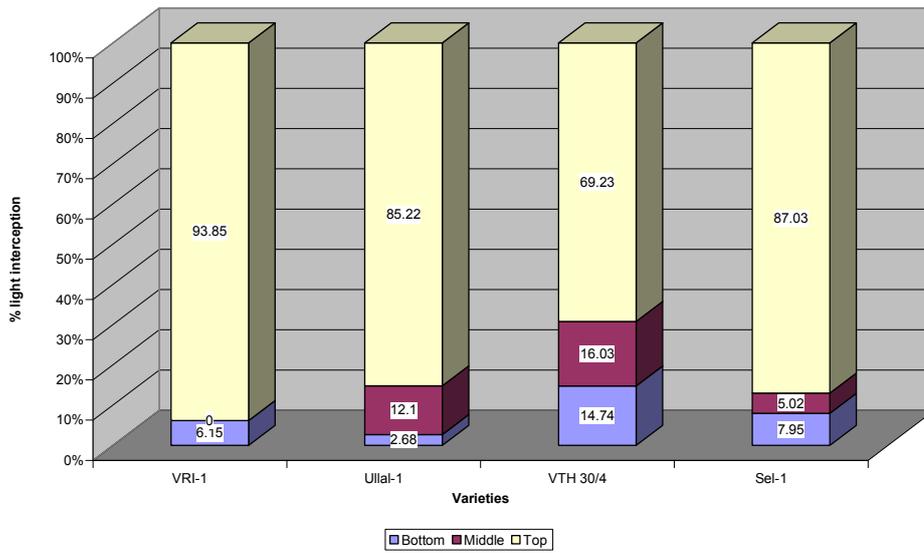


Fig. 6.2: Light interception in different cashew varieties

Fig.3: Effect of pruning on light interception

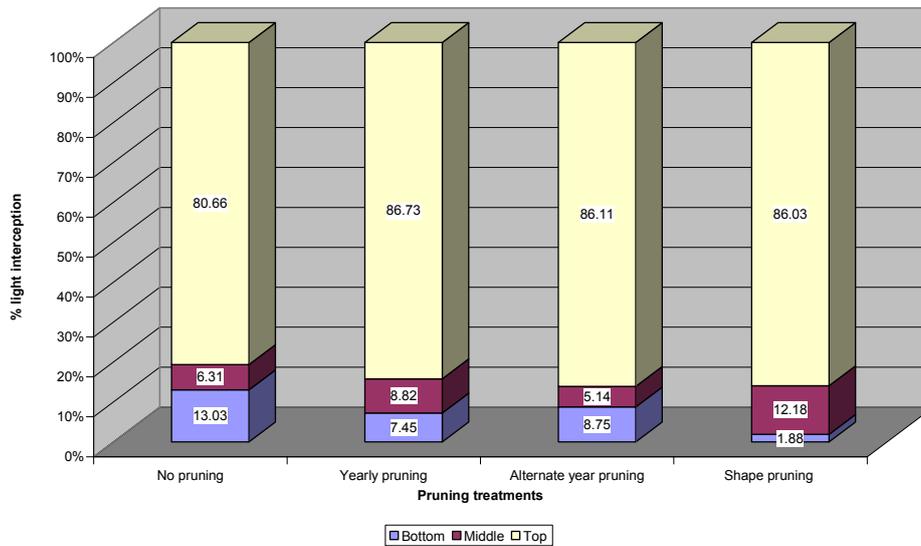


Fig. 6.3: Effect of pruning on light interception

### **6.3 Studies Bioecology and management of lepidopteran flower and fruit pests of cashew.**

Project Leader	Dr. D. Sundararaju
Project Number	3.9
Project Duration	2003 - 2006

#### **6.3.1 Introduction**

Even though, cashew is mainly affected by two major pests (cashew stem and root borer and tea mosquito bug), reports about occurrence of lepidopteran flower and fruit pests had also been documented. For management of these pests, at present, there is a general guideline which indicates that the insecticides recommended for management of tea mosquito bug (TMB) could also manage these pests. Therefore, detailed studies were undertaken to find out the exact yield loss caused by these pests. Their species compositions including their natural enemies were also studied. Further studies were undertaken to estimate the exact level of management of these pests by application of promising insecticides recommended for management of TMB. Thereby, a common insecticide will be finalized and that can effectively manage all above pests.

#### **6.3.2 Objectives**

- To record exact species of lepidopterous flower and fruit pests occurring in west and east coast.
- To undertake yield loss assessment due to above pest.
- To estimate the extent of management of above pests by recommended insecticides used for management of tea mosquito bug (TMB).

#### **6.3.3 Results and discussion**

The studies were conducted for three years on yield loss due to lepidopteran flower and fruit pests on Bhaskara cashew variety at NRCC Experimental Station, Shanthigodu after excluding TMB attack. The results indicated that out of total panicles used in the studies, harvestable fruit set was observed on 86.4 to 94.5 per cent of panicles treated with insecticide (lambda cyhalothrin); whereas in the untreated control, harvestable fruit set was observed only on 51.7 to 62.7 per cent of panicles. As a result, treated panicles had higher harvestable nuts (3.85 to 4.69 nuts / panicle) than the untreated panicles (0.98 to 1.66 nuts / panicle). Thus from yield loss studies, it was found that in the absence of TMB attack, with timely control of lepidopteran flower pests alone can lead to two to three fold increase in yield. The yield loss ranged from 61.7 to 74.5 per cent (Table 6.13)

In order to find out the exact species composition damaging cashew flowers and fruits, a survey was conducted at coastal Karnataka and coastal Tamil Nadu for three years (2000-04 to 2005-06). Based on the nature of damage, they were classified as major and minor pests and listed in Table 6.14.

The apple and nut borer (*Thylacoptila paurosema*) was parasitized by two species of hymenopteran larval parasitoids during December to April in the coastal Karnataka. The over all larval parasitism ranged from 15.3 to 50.0 per cent. In the west coast, larval parasitism upto 25.0 percent was recorded on the shoot tip caterpillar (*Hypatima haligramma*). The apple and nut borer (*Thylacoptila paurosema*) was recorded for the first time on a new weed host plant (*Cassia alata*, Candle brush, an ornamental plant introduced from Argentina). Similarly *Archips* spp. were also recorded on *Crotolaria* sp. and also parasitized by *Apanteles* sp. The larvae of *Aetholix flavibasalis* were parasitized by larval parasitoids of cashew leaf miner, shoot tip caterpillar and apple and nut borer. Occurrence of eggs of chrysopid predator either in groups or singly was observed on flowering panicles of cashew.

Two insecticides (lambda-cyhalothrin 0.003% and carbaryl 0.1%) reported promising against TMB were evaluated against these flower pests for two years (2004-05 and 2005-06) on VRI-1 cashew variety in a larger plot at Shanthigodu. Three rounds of spray coinciding with flushing, flowering and fruiting were given. The results indicated that even though both insecticides controlled TMB very effectively, lambda-cyhalothrin had shown highest residual action than carbaryl in preventing the build up of all lepidopteran flower and pests (Table 6.15). Subsequently the terminal residue for lambda-cyhalothrin in the kernels was also analysed with help of CEPC Laboratory, Kollam, Kerala and its residue in the kernels could not be detected even upto the level of 0.01 ppm level. In conclusion, lambda-cyhalothrin can very well be recommended for management of all above mentioned pests (TMB and lepidopteran flower and fruit pests), as it had also shown highest cost benefit ratio (Table 6.16).

#### **6.3.4 Conclusions**

Lambda-cyhalothrin 0.003 per cent can be recommended for management of TMB and lepidopteran flower and fruit pests, as it had also shown highest cost benefit ratio.

#### **6.3.5 Publication**

Sundararaju, D. 2006. The yield loss due to lepidopteran flower and fruit pests and their species composition and management on cashew. *Cashew News* 11 (2) : 2.

**Table 6.13: Yield loss assessment due to lepidopteran flower and fruit pests on 'Bhaskara' cashew variety**

Year	Nuts/ panicle		
	Protected	Unprotected	% loss
2003-04	3.85±0.31 <sup>a</sup>	0.98±0.14 <sup>b</sup>	74.5
2004-05	4.69±0.32 <sup>a</sup>	1.64±0.19 <sup>b</sup>	65.0
2005-06	4.33±0.33 <sup>a</sup>	1.66±0.24 <sup>b</sup>	61.7

± Values are Standard Error. In the row, values followed by different letters indicates significant difference by paired 't' test at 1.0% level.

**Table 6.14: List of flower and fruit pests recorded in coastal Karnataka and coastal Tamil Nadu**

Coastal Karnataka	Coastal Tamil Nadu
<b>Major Pests :</b>	
Shoot tip caterpillars, <i>Hypatima haligramma</i> M. and <i>Anarsia epotias</i> M.	Shoot tip caterpillars, <i>Hypatima haligramma</i> M. and <i>Anarsia epotias</i> M.
Apple and nut borer, <i>Thylacoptila paurosema</i> M.	Apple and nut borer, <i>Thylacoptila paurosema</i> M.
Unidentified noctuid	Leaf and blossom webber, <i>Lamida moncusalis</i> W.
<b>Minor Pests :</b>	
<i>Archips</i> spp.*, <i>Rapala</i> sp.*, <i>Aetholix flavibasalis</i> *, <i>Oenopsila flavifuscata</i> , <i>Pingasa ruginaria</i> , <i>Anigrea albomaculata</i> , <i>Euproctis scintillans</i> , <i>Lamida moncusalis</i> and Three unidentified pyralids.	<i>Sylepta balteata</i> , <i>Euproctis scintillans</i> and one unidentified noctuid.

**Table 6.15: Evaluation of promising insecticides against flower pests in large plot trial of 2004-05 and 2005-06 on VRI-1 cashew variety.**

Treatment	Flower infesting caterpillars* (mean no./m <sup>2</sup> ) after			Species composition (Shoot tip caterpillars : others) after		
	1 <sup>st</sup> spray	2 <sup>nd</sup> spray	3 <sup>rd</sup> spray	1 <sup>st</sup> spray	2 <sup>nd</sup> spray	3 <sup>rd</sup> spray
<b>2004-05</b>						
Carbaryl 0.1%	0.50	1.20	0.15	1:0.43	1:0.20	1:0.5
λ-cyhalothrin 0.003%	1.95	0.25	0.00	1:0.50	1:0.25	-
<b>2005-06</b>						
Carbaryl 0.1%	0.00	2.44	0.00	-	1.0 : 1.6	-
λ-cyhalothrin 0.003%	0.00	0.25	0.00	-	1.0 : 0.7	-

\* Estimated by drop cloth method in a total of 25 m<sup>2</sup> area.

**Table 6.16: Evaluation of insecticides in large plot trial of VRI-1 during 2005-06 – economic analysis.**

Treatment	Yield kg/tree		Yield loss against carbaryl (kg/tree) <sup>a</sup>	Yield contribution due to insecticide (kg/tree) <sup>b</sup>	Gross profit (Rs./tree) <sup>c</sup>	Cost of insecticide application (Rs./tree) <sup>d</sup>	Net gain (Rs./tree) <sup>e</sup>	Gain from insecticide <sup>f</sup>	Benefit cost ratio <sup>g</sup>
	Sample trees	Whole plot							
Carbaryl	3.98	2.88	0.0	1.71	101	22	79	38	2.73
Cyhalothrin	3.94	2.97	0.0	1.80	104	14	90	49	4.50
Control	1.23	1.17	1.71	0.0	41	0	41	0	

a = Yield of carbaryl treated tree – yield of the treatment

b = Yield of the insecticidal treatment – yield of control

c = Yield in kg/tree X Rs. 35/-

d = Cost of insecticides + cost of application

e = Gross profit – Cost of insecticide application

f = Net gain of insecticidal treatment – Net gain of control

g = (Gross profit of insecticidal treatment – Gross profit of control) / cost of insecticide application

## 6.4 Foraging behaviour of pollinators of cashew

Project Leader	Dr. D. Sundararaju
Project Number	3.12
Project Duration	2003 - 2006

### 6.4.1 Introduction

Under west coast, halictid bee (*Pseudopsis oxybeloides*), anthophorid bee (*Pithitis smaragdula*), honey bee (*Apis cerana indica*) and wasp (*Odynerus* sp.) are reported as possible pollinators of cashew. Under east coast, fly pollination was commonly reported. In these studies extent of pollination under insecticidal ecosystem has not been reported. However the studies taken at this centre had indicated that the possible pollinators are halictid bees and the extent of pollination due to insecticidal spraying was not affected. Therefore detailed studies were undertaken in all above aspects.

### 6.4.2 Objectives

- To record exact species of pollinators and extent of pollination in the insecticide sprayed ecosystem of traditional and non-traditional area of cashew in the east coast.
- To determine whether honey bees are reliable or unreliable pollinators of cashew.
- To devise a safety method or conservative method for honey bees in the insecticide sprayed ecosystem of cashew.

### 6.4.3 Results and discussion

The results indicated that 4 - 7 species of pollinators constantly visited cashew flowers in both coastal Karnataka (*Pseudopsis oxybeloides*, *Lasioglossum* sp., *Braunsapis* sp., *Ceratina* sp. and *Pithitis smaragdula*) and coastal Tamil Nadu (*Homalictus* sp., *Braunsapis* sp., *P. smaragdula* and *P. oxybeloides*). Even though, honeybees visited cashew flowers; they collected nectar only. The stingless bees (*Trigona irridipennis*) collected both nectar and pollen grains. But, the pollen grains were loaded in the form of dark brownish slimy mass. In the case of honey bees, the pollen grains were also in the form of dark brownish glued mass.

Visit of pollinators at fixed hours and fixed spot on cashew (flowering season) were made during 2005-06 for a duration of 10 minutes. For this purpose one square meter of the canopy was marked in early season (NRCC Sel-2), mid season (Bhaskara) and late season (Chintamani- 1) flowering varieties. On NRCC Sel-2, the main pollinator visited was found to be stingless bee (*Trigona irridipennis*), whereas on Bhaskara, the short tongued bees (non-*Apis* spp.) visited highest and on Chintamani, both *T. irridipennis* and short tongued bees visited as main pollinators. The early, mid and late season varieties had recorded visit of bees as 0.35, 0.16 and 0.09 pollinator/ panicle/ day respectively. At same time when the population of bees visiting neighbouring avenue flowering tree (*Peltophorum ferrugineum* (Decne.) Benth) was observed, it was found that *T. irridipennis* visited as 13.5/ panicle (as an instant spot count). Thus, cashew had a very low visit of bees when compared to other high nectar producing tree.

The extent of pollination was assessed from insecticide treated plots through stereoscopic microscope by observing deposit of pollen grains on the stigma of hermaphrodite flowers. The extent of pollination was assessed for the three seasons on seven varieties (V-1, V4, NRCC Sel-2, Bhaskara, Ullal-3, Dhana and VRI-3) and it ranged from 16.9 to 49.5 per cent and at coastal Tamil Nadu, pollination deficit (pollination less than 25.0%) was observed at Vridhachalam and it needs in depth study to improve the pollination. However, in the insecticide treated plots, the extent of pollination was normal except at Vridhachalam.

Immediately after first, second and third round of spray, mortality of honey bees was assessed by drop cloth method. Even after six hours of spray, no dead bees were observed on the drop cloth. Further, the apiaries near the vicinity of sprayed plots were also observed for mortality of bees and no mortality of honeybees could be seen.

But in a plot of NRCC Sel -2 where activities of *T. irridipennis* were seen in a high level, a general spray of  $\lambda$ - cyhalothrin (0.003%) was given and after the spray, its activities ceased on that particular day of spraying only and subsequently resumed on next day itself. Similar trend was also seen for *Apis cerana indica* which generally visits cashew at a low level only. But with regard to *A.florea*, on the day of spraying, stray death of bees was seen in the plot itself and subsequently its visit was sighted only after fifteenth day of spraying.

#### **6.4.4 Conclusion**

Under coastal Karnataka, the extent of pollination was normal and in the traditional cashew belt of Tamil Nadu, pollination deficit was observed. Therefore suitable studies for management of pollinators are required and thereby productivity can be enhanced. In general, visit of honey bees on cashew was in a low level only.

#### **6.4.5 Publication**

Sundararaju, D. 2003. Occurrence of bee fauna and extent of pollination in insecticide sprayed ecosystem of cashew. *J. Polynol.* **39** : 121-125.

## 6.5 Studies on pheromone of tea mosquito bug (TMB) *Helopeltis antonii* S.

Project Leader	Dr. PS Bhat
Project Associate	Dr. TN Raviprasad
Project Number	3.7
Project Duration	2000 - 2006

### 6.5.1 Introduction

The earlier studies had given Indications regarding the presence of sex pheromone in TMB (*H. antonii*) infesting cashew. The sex attractions in *Helopeltis* spp. were quite strong when compared to other group of mirid bugs. Hence, a project was under taken to identify and utilize the pheromones in Integrated Pest Management Programme.

### 6.5.2 Objectives

- Identification of pheromonal blend emitted by TMB.
- Development of controlled systems for use in monitoring or mass trapping as a tool in Integrated Pest Management Programme.

### 6.5.3 Results and discussion

#### 6.5.3.1 Electroantennogram studies with extracts

Extracts of whole body, abdomen and thoracic parts of adult female bugs of tea mosquito bugs (TMB) were collected in n-hexane, dichloromethane and petroleum ether. These extracts were tested by Electroantennogram (EAG) for the response from male TMB at Project Directorate of Biological Control, Bangalore. Antenna separated from male insect was fixed onto EAG and the response in millivolts (mv) was recorded for individual extracts. The response was higher for whole body extracts in dichloromethane (-0.813 mv) compared to -0.275 mv for dichloromethane alone. Whole body extracts in petroleum ether also elicited higher response (-0.703 mv) compared to -0.408 mv when petroleum ether was tested alone. The Response was highest in the case of antennae separated out from 4 day old male TMB.

#### 6.5.3.2 Characterization of response inducing compounds

##### Body extracts

Characterization of body extracts was done at PDBC, Bangalore by following Rembold's method using GCMS. The compounds with more than 90 per cent matching were toluene, cyclohexanol, delta.3-carene, dodecane, beta – pinene, 1,2- benzenedicarboxylic acid, tetradecamethyl cyclohepta , Siloxane, pentadecane ,heptadecane , octadecane, trans-geraniol 2,6 octadien-1-O , 1-beta pinene bicyclo, 4-tert-butyl-1,2 benzenedithiol, and tetra deconic acid methyl ester.

The subsequent GCMS studies helped in identifying several 18 compounds viz., 1,2 benzenedicarboxylic acid, diethyl ester, ethyl phthalate, diethyl phthalate, anozol, phthalol, solvanol, neantine, placidol E, unimoll DA, palatinol A, diethyl o- phenylenedia

cetate, phthalic acid, diethyl ester, benzene, 1-ethyl-4,5,8-trimethylnaphthalene, 4-tert-butyl-1,2-benzenedithiol and 2-ethyl-1-3,4-trimethylnaphthalene.

### Volatiles

The volatiles collected from virgin female and field collected in dichloromethane (DCM) by enclosing the laboratory reared and field collected adult TMB bugs by cold suction set up were prepared for injection into GCMS. The analyses were carried out by following Anani and Miridi methods. These volatiles had a few compounds which were not detected in the earlier GCMS analyses (Table 6.17).

### Confirmatory EAG analyses

Electroantennogram studies were conducted using some of the compounds identified in the GCMS studies. The response recorded was highest for the volatiles collected from virgin females (-1.058mv) followed by cyclohexanol (-0.717mv) and deconic acid (-0.634mv).

### 6.5.4 Conclusions

The Electroantennogram response was higher for whole body extracts and volatiles from virgin TMB in dichloromethane. The volatiles collected from the virgin female contained 24 compounds including methyl butyrate as revealed in the GCMS analyses. Field trials need to be initiated to study the response of these compounds in attracting the male TMB.

**Table 6.17. Compound identified in the GCMS analyses by following Anani M and Miridi. M methods**

Anani.M	Miridi.M
Hexanol	Methyl butyrate
Cyclohexanol	Cyclohexanol
Alpha pinene	Alpha pinene
Dodecane	Beta-pinene
1,2-Benzenedicarboxylic acid	Beta myrcene
Heptadecane	Napthalene
4-tert-butyl-1, -benzenedithiol	Dodecane
2-Ethyl-1, 2,4-trimethylnaphthalene	Benzothiazol
1-Ethyl-4, 5,8-trimethylnaphthalene	cyclohexane
Benzene	triacontane
Hexadecanoic acid	Dotriacontane
1-Phenanthrene carboxylic acid	Dodecanoic acid
	Hexadecane
	Methanone
	Octadecane
	Hepatdecane
	1,2-Benzenedicarboxylic acid
	Hexadecanoic acid

## 6.6 Developing economically viable on-farm cashewnut processing

Project Leader	Dr. D. Balasubramanian
Project Number	4.7
Project Duration	2000 - 2006

### 6.6.1 Introduction

Large-scale industries serve as backbone of national economy, while small-scale processing in rural area act as a survival backbone of majority of people. The quickest and cheapest way for rural development is to encourage appropriate on farm processing. In view of high share of raw cashew nut in the cost of processing (70%), declining trend in the unit value of raw nut price, nut harvest at immature stage, socio economic position of cashew farmers, this project was contemplated with the primary goal of promoting on farm/homestead processing to escalate the economic status of farming community.

### 6.6.2 Objectives

- To evaluate current on-farm primary processing practices followed by growers and compare them with improved technologies available. Identify and specify interventions needed.
- To develop technically superior and economically viable solutions where appropriate technologies are not available.
- To install a commercially viable cashew nut-processing pilot plant NRCC for performance evaluation, refinement, and training for commercial exploitation.
- Entrepreneurship development on successful pilot plant studies and other field worthy technologies.
- Preparations of techno-economic feasibility reports

### 6.6.3 Results and discussion

#### **Status of small scale cashewnut processing in Sindhudurg district, Maharashtra**

The small-scale cashew nut processing technology followed in Sindhudurg district is developed in consideration of resources and need. Technological design maintains a balance between human and machine energy to strengthen work opportunities. The major emphasis is given on integration of the rural manpower at farm and household in to overall system. Over 350 firms operating in seven taluks constitute small scale cashewnut processing sector with their capacity utilization is in the range of 2-12 TPA.

#### **Operation**

Survey data reveals that raw nuts are either sourced from own / neighbouring farm and/or from local traders. The nuts dried under sun in single layer for a day or two to reduce the moisture level. Steam boiling technique is predominantly followed and three types of boilers viz., Direct steaming vertical type, direct steaming horizontal type, and compact type are being used for nut conditioning. Nut shelling is done using hand cum pedal operated shellers and average operational capacity is around 20kg/head/day with whole

kernel recovery of 80-90%. Extracted kernels are subjected to hot air maintained at 70°C for 6 to 8 hours. Peeling is done manually and the operational capacity ranges between 4 to 6 kg/head/day depending on their skill and experience. After skin removal, the kernels are graded in to wholes and broken and packed in polythene bags.

### **Kernel market**

The cluster based cashew program (promoted by NABARD) helps to trade kernels produced from small-scale units. Kernel market is on upswing from March as processing starts during this period. The rates in the wholesale market speculate from Rs. 230/- to Rs. 300/- per kg depending on the grade. The kernel market is promoted through traditional fairs and helps to market the product directly to the consumers waiving commission agents and the distributors and their monopolized trade practice.

### **Technical training and financial support**

Access to the supporting services brings success to the technology adoption. Certain organizations viz., Hegdewar prakalp and Ratnagiri Zilla Khadi Sangh are acting as an effective instrument to impart training skills. Training is conducted as vocational level through “learning by doing” to become proficient and confident in application of technology at work. . Training program focused on improving group activity, technical skill development, market support and value addition of low-grade kernels. Financial support for the purchase of processing machinery is provided by State Agriculture dept., and KVIC.

### **Merits of small scale cashew nut processing**

- High capital investment for establishing large-scale industries (infrastructures and machineries) whereas processing is done in small-scale level requires less capital investment up to Rs 60, 000 only (Table 6.18).
- In case of small scale cashew processing, the installed capacity is around 12 TPA, requiring relatively lesser working capital.
- More technical manpower is requisite in large-scale industries, whereas in small-scale level, family members get employment in the non-farming season.
- Moreover scattered manpower in a village can be utilized effectively.
- High level and effective management is a requisite in large-scale industries for better rate of return. In small scale processing, management and labour cost are less reducing cost of processing.
- Generate rural employment and improve economic growth of farming sector.

### **Interventions required**

- Establishing supply chain for raw cashew nuts and developing quality standards for raw cashew nuts
- Optimizing processing parameters for better whole kernel recovery at packaging stage
- Setting up common service centre or facility provider for small-scale processors in respect of value addition and packaging.

- Low cost CNSL extraction technique suiting to cooperative level and linking up with user industries
- Strengthening of machinery provider for improving technical specifications

### **Economic feasibility**

Appropriate technology is not only the technology relevant to the needs for whom it is designed. It is socially appropriate, economically accessible and can be used and maintained in the local environment without causing damage. On farm cashew nut processing is a household technology package tailored to escalate the economic status of farm sector. The feasibility of small-scale cashew processing units reveals that the net value addition per unit at farm level is worked out to be Rs 13425 and the value addition per unit weight of raw cashew nut is around Rs. 22. The economics for the unit having utilization capacity of 3 TPA is found out as Rs. 14520 per month (Table 6.19). Besides, about 300 man-days per unit have been generated during season.

### **Cashew nut processing**

Raw cashew nuts are dried under sun for 2 days after harvest to reduce the moisture level. Presently, raw nuts are steam treated and semi-mechanized shellers are used to extract kernels. Women labourers are engaged in shelling and their operational capacity is in the range of 30 to 50 Kg raw nuts per day per head with whole kernel recovery between 73 to 85 %. Conventional drying technique is followed (mud construction) to dry kernels and ease peeling process. Gas fired drier for kernel is also available wherein LPG is used as fuel to heat the incoming air. The temperature can be controlled by two-stage burner, which can operate at high and low flame automatically.

Peeling of kernels is done manually using knife at home level. Peeling efficiency in terms of whole kernel is around 78 %, which is comparatively lower than peeling efficiency recorded in Dakshina Kannada district i.e. 85 per cent. Kernels are sorted manually in to 15 grades based on colour and wholesomeness and packed in polythene bags.

### **Kernel marketing**

Kernel market in Mangalore district serves as benchmark to fix up price of kernel supplied from this region. After packing kernels in polythene bags and transported to retail outlets in taluk headquarters or to wholesale market, confectioneries or bakeries situated in Bangalore. Although vita packing and molded vacuum packaging machineries are available in few units, it is not used due to extra cost to be incurred on packaging and lack of interest at selling points.

### **Economic feasibility**

Comparative economic feasibility of existing method and small-scale processing is presented in Table 6.20. Based on the production of raw cashew nuts in this region, about 79 units could be started with existing system of processing set up with the utilized capacity up to 64 TPA. Introducing small-scale processing units can increase the number of units to 635, generating employment to 3177 persons which is twice more than the employment generation with the existing set up for the total raw nut production. As the production efficiency at various stages of operation in the current system is inferior, the unit weight value addition is worked out to be Rs 9.55 / kg of raw

nuts against Rs. 11.05 / kg in the case of small-scale processing system with operational capacity of 8 TPA. Inefficient technical and management aspects are the due reasons lowering profitability. In view of better utilization of processing facility developed, employment generation, profitability of business and capital investment, small-scale cashew nut processing is highly feasible in this region.

### **Optimisation of processing parameters using small scale cashew processing machinery**

Cashew processing machinery viz. vertical type direct steam boiler (40 kg raw cashew nut capacity) and electrically operated tray type kernel drier (25 kg kernel capacity) were optimized for its operational parameters. The critical parameters influencing the whole kernel recovery for steam boiler i.e. steam pressure and period of exposure and for kernel drier i.e. hot air temperature and duration were optimized. The moisture content of the raw nut samples by toluene distillation method was found to be in the range of 8.3 – 9.7 % d.b. showing that the nuts were well dried before supplying to processing line. In order to optimize nut conditioning parameters, the nuts were subjected to various steam pressure viz., 60, 70, 80 90 PSI for 7, 11, 15 and 19 minutes in different batches. Conditioned nuts were shelled using hand cum pedal operated Sheller to extract the kernels. The shelled kernels were sorted out and analyzed for its qualitative efficiency. Kernels, thus extracted were subjected to hot air drying to enable skin removal carefully. After manual peeling, index value was worked out based on end product.

Kernel drying parameters were optimized by treating the nuts to predetermined values i.e. 72 PSI for 14 minutes and shelled to extract whole kernels. Whole kernels were then exposed to hot air maintained at 60, 70, 80 and 90 °C for 4, 6, 8 and 10 hours in different batches. At the end, the kernels were peeled manually and sorted in to wholes, broken, rejects and hard to peel kernels and analyzed. During peeling operation, the ease of peeling and colour of the kernels were observed for every batch to assess the effect of various technical parameters.

Product value method was followed to evaluate the cashew nut processing units. In this method, the kernel obtained after each experiment was valued by multiplying the prevailing kernel price. Based on the index value obtained and following optimization technique, the critical values at which better kernel grades could be worked out. Data revealed that the nuts could be conditioned at 70 to 75 PSI for 13 to 15 minutes in small scale steam boiling unit for maximum recovery of whole kernels in shelling. Further extracted kernels could be exposed in hot air in electrically operated tray drier maintained at temperature in the range of 70 to 75°C for 6 to 7 hours to yield high value end product (Fig 6.4 and 6.5).

A rectangular platform is with handle and four wheels provided for the mobility and a detachable type LPG gas burner is fitted to steam boiler as thermal source. Experimental results with LPG burner revealed that the nut conditioning could be completed in half the time required in comparison to fire wood as heat energy. A pilot plant for small scale cashew nut processing has been developed at NRC for cashew. Facility developed could be used to train farming community to impart skills at various stages of cashewnut processing.

### **6.6.4 Conclusions**

Potential users and manufacturers of technology have been convinced about the technical and economic feasibility of products. Local participation of processors in Maharashtra indicates that they are mentally prepared and accept the change. The relative merits of small-scale cashew nut processing over large-scale industries justifies that it ideally suits

for farm level / homestead processing. Considering the role of small-scale enterprises at farm level, entrepreneurs shall be encouraged to plunge actively in to this sector. The growth of small scale cashew processing units in Sindhudurg clearly indicates the technology adoption and the profitability of business.

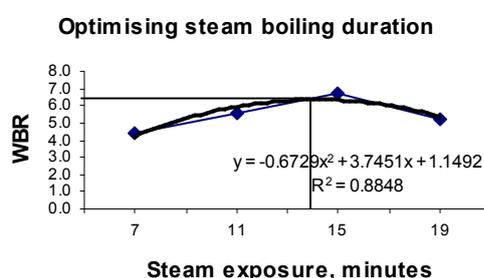
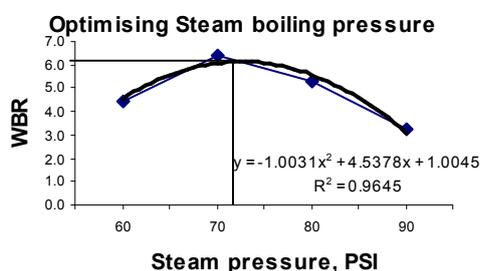
**Table 6.18. Cost of cashew machinery for small-scale Cashew nut processing**

Sl. No	Machine/ tools	Cost/unit (Rs)	Required qty.	Total cost* (Rs)
1	Cashew steam boiler (40 kg/batch)	24500	1	24000
2	Hand cum pedal operated Sheller	1750	2	3500
3	Cashew kernel drier (500 watts)	27500	1	27500
4	Weighing scales (2 & 5 kg)	3000	1	3000
6	Plastic crates & accessories	500	-	500
7	Plastic sealing unit	1500	1	1500
<b>Total</b>				<b>60000</b>

\* Prices quoted with reference to year 2006

**Table 6.19. Economic feasibility of small scale Cashew nut processing**

Feasibility		Cost economics	
Number of cashew trees (Average)	100	Processing capacity /day (Kg)	40
Raw cashew nut production @ 6 kg/tree (Average)	600	Quantity of processing / year (Kg)	3000
Receipt from RCN @ Rs 33/kg	Rs.19800	Market price/kg (moisture loss – 3%)	Rs 35
Shelling % (KPR)	25%	Raw material cost @ Rs36/kg	Rs 108000
Receipt after processing (Wholes: Broken ratio is 4:1)	Rs.32100	Labour cost	Rs 12100
Receipt through Cashew shell @ Rs 2.5/kg	Rs.1125	Electricity, fuel & other expenses	Rs 3000
Total income	Rs. 33225	Total processing cost	Rs 123100
Net value addition	Rs. 13425	Sales	Rs 166650
Unit weight benefit	Rs. 55	Profit	Rs 43550
Value addition per unit weight	Rs. 22	Profit / month	Rs. 14520



**Fig 6.4. Optimized values of technical parameters – Steam boiler (40 kg capacity)**

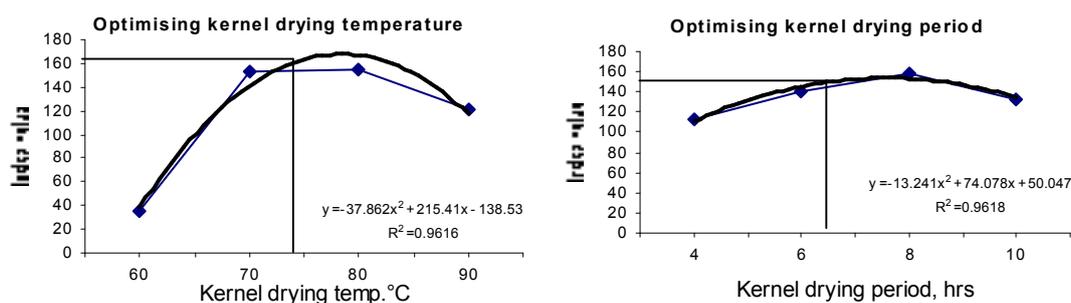


Fig 6.5. Optimized values of technical parameters – Kernel drier (25 kg capacity)

Table 6.20. Economic feasibility of cashew nut processing in Kolar region

<b>I. FEASIBILITY OF PROCESSING</b>	<b>Current method</b>	<b>Small-scale</b>
Raw nut production (Kg)	5083000	
Processing capacity / batch (Kg)	320	40
Number of batches per month	25	25
Utilized capacity per annum (Kg)	64000	8000
Possible number of units	79	635
Employment generation	1588	3177
Number of man days generated	317688	635375
<b>II. ECONOMICS OF PROCESSING</b>	(In Rupees)	
<b>RECEIPTS</b>		
Sales realization of kernels	3044780	414727
Sales realization of shell	112000	14000
Total sales	3156780	428727
<b>COST OF PROCESSING</b>		
Raw nut @ Rs 32 per Kg	2048000	256000
<b>LABOUR COST</b>		
Steam boiling & Kernel drying @ Rs 60/day	12000	8000
Shelling @ 45 Kg/day	67392	9720
Peeling @ 11 Kg/ day	46986	9234
Grading & Packaging @ 30 kg/day	11437	9800
Fuel cost @ 0.1 % of raw nuts processed	2048	1000
<b>PACKAGING COST</b>		
	4000	500
<b>OTHERS</b>		
Administrative expenses@ 0.1 % of produce value	2262	NA
Transport costs @0.25 % of produce value	5654	NA
Total expenditure	2199779	294254
Interest on term loan	28304	6400
Interest on working capital	317440	39680
<b>Earnings before income tax (EBIT)</b>	<b>611258</b>	<b>88393</b>
<b>Benefit/Kg</b>	<b>9.55</b>	<b>11.05</b>
<b>Benefit cost ratio</b>	<b>1:1.28</b>	<b>1:1.30</b>

Whole kernel recovery in shelling and peeling are 78% and 76 % only : NA – Negligible amount

### 6.6.5 Publications

- Balsubramanian, D. 2006. Improving Whole Kernel recovery in processing – Specific to Cashew nuts of Nigeria origin. *Agricultural mechanization in Asia, Africa & Latin America*. Vol.37(1):58-64
- Balsubramanian, D. 2006. Moisture Desorption Characteristics of Cashew kernels. *The Cashew*. Vol. 20(1):13-19.
- Balsubramanian, D. 2003. Cashew nut processing and its Feasibility in Chintamani district of Karnataka – A Case Study. *The Cashew*.17 (4): 6-11.
- Balsubramanian, D. 2003. Small scale cashewnut processing – An appropriate technology for rural development. In: *Downsizing Technology for Rural Development*, Eds. Khuntia, S; Parida, A. and Mishra, M.N. Vol.II, p.632. (Published by .....)

## 6.7 Studies on preparation of nutraceuticals from cashew apple

Project Leader	Dr. K.V.Nagaraja
Project Number	4.9
Project Duration	2004 - 2007

### 6.7.1 Introduction

Cashew apples are currently fermented to an alcoholic beverage called Feni in Goa. However, in rest of the cashew growing states, it is not being utilized. Nutraceuticals are compounds occurring in various fruits. These include complex carbohydrates, fatty acids, minerals, carotenoids, pigments, amino acids etc. As cashew apples are known to contain some of these, attempts are being made in the project to extract these from cashew apple powder and to characterize them.

### 6.7.2 Objectives

- The major objectives of the project were isolation and characterization of nutraceuticals from cashew apple powder of released varieties.

### 6.7.3 Results and Discussion

#### Preparation of cashew apple powder

Fully mature cashew apples after harvest were washed with water and cut into thin slices (3 to 4 mm) and sun dried for a period of 5 days (8h/day). Despite sun drying for 5 days, the apple slices were still leathery requiring further drying. As such sun dried apple slices were further dried in air flow cabinet drying at 70°C for 2 days. Cashew apple slices thus dried were powdered and sieved through 60 mesh sieve.

Alternatively, cashew apples after harvest were washed with water thoroughly and autoclaved at 16 PSI for 10 min. Autoclaved cashew apples were sliced and dried at 70°C for 2 days in air flow cabinet dryer. Compared to sun drying, cashew apple powder obtained by autoclaving and drying was better in terms of appearance.

#### Biochemical analysis

These powders were used for all the biochemical analysis. The sun dried cashew apple powder was analysed for various biochemical constituents (Table 6.21). Significant varietal variation was noticed for protein content (4.26 and 12.29%), starch (6.75 – 28.66), sugars (11.44 – 42.04%) and in vitro digestibility of carbohydrates of cashew apple powder (0.8 – 17.21 mg maltose released /3h/100 mg). Cashew apple powder of variety Chintamani-1 had higher protein (12.29%) content. Cashew apple powder of variety BLA-39-4 had higher starch (28.66%) and lower peroxide (0.772 n moles NDA/100 mg) contents. Phytic acid, an antinutritional factor has not been detected in cashew apple powder.

## Extraction of pectin

Cashew apple powder was extracted at acidic pH (pH 1) for 1 h under boiling conditions followed by concentration to 1/3<sup>rd</sup> its volume. Pectin was precipitated from the concentrate by the addition of excess ethyl alcohol followed by washing with either and drying. As the procedure involves boiling, Vitamin C, one of the important antioxidant present in cashew apple gets destroyed. As such milder extraction procedure needs to be attempted. Using similar methods, pectins from other sources like tight skinned orange peel, pulp, lime, apple and cashew apple pomace was extracted for comparison. The pectin thus isolated was characterized for equivalent weight, acetyl content, ash content and methoxyl content. Results are presented in Table 6.22. Compared to other sources, pectin extracted from cashew apple pomace and cashew apple powder had low ash content. Pectin's yield from cashew apple powder, pomace and cashew apple waste varied between 1.44 and 2.59%. The yield of pectin was high (10.11%) in case of tight skinned orange pulp. Compared to commercial sample of pectin, pectin extracted from cashew apple pomace, cashew apple powder and cashew apple waste had lower methoxyl content.

The pectin extracted from different sources was washed at 600°C for 6 h and the ash was dissolved in 0.1 NHCl and analysed for Ca, Mg, K and Na by AAS. Results are presented in Table 6.23. Although ash content of pectin of cashew apple powder was quite less, Ca, Mg, K, and Na contents was higher compared to other sources. In all the pectin samples analysed, Ca content was higher than Mg, K and Na. Except cashew apple powder where K concentration was higher than Ca, Mg and Na.

Attempts were made to extract pectin from cashew apple powder (Red) using 0.5% sodium hexa metaphosphate pH 4, Ammonium oxalate and oxalic acid solution pH 4, 0.05 NHCl and distilled water pH 5.0 by boiling for 60 min followed by concentration to 1/3<sup>rd</sup> of its original volume and precipitation with isopropanol containing 0.01 NHCl and washing the precipitate with isopropanol and drying. The pectin thus isolated was characterized and results are presented in Table 6.24. Acidic extraction (0.05 NHCl) followed by precipitation with isopropanol resulted in higher yield (4.09%) with lesser ash content (1.15%). The purity of the pectin assessed as galacturonic acid by carbazole method indicated that extraction with distilled water at pH 5 yielded pectin of 25.61 per cent purity. Extraction with 0.5 N sodium hexa metaphosphate appeared to be not suitable as the ash content was very high (16.21%). Pectin extracted with all the extractants had low methoxyl content ranging between 5.04 and 6.37 per cent. K content of the pectin was higher compared to Ca, Mg and Na with all the extractants used for extraction.

Attempts were made to extract and fractionate the carbohydrates of cashew apple powder and cashew apple pomace 50 g of sample was fractionated into different fractions as per reported protocol. Results are presented in Table 6.25. Concentration of carbohydrate contributing to insoluble crude fibre (cellulose, hemicellulose A and B) was higher in both cashew apple pomace compared to pectin, the soluble crude fibre.

Cashew apple powder and pomace were extracted (soxhlet for 4 h) with n-hexane and the n-hexane extract was treated with activated charcoal and anhydrous sodium sulphate to remove pigments and water and concentrated. A known volume of the lipid concentrate was fractionated into neutral lipids (CHCl<sub>3</sub> elution), glycolipids (acetone elution) and phospholipids (methanol elution) by silicic acid chromatography. Results are presented in Table 6.26. The total lipid among different samples of cashew apples powder varied (0.94 to 3.25%). The major lipid fraction is neutral lipid in all the samples except cashew apple powder where glycolipid was the major lipid fraction (70-27%). In all the samples, phospholipids concentration was least ranging between 1.27 to 31.43

per cent except cashew apple waste (ICAR Research Complex, Goa) and cashew apple powder (red).

The lipid fractions such as neutral lipid, glycolipid and phospholipids were saponified with alcoholic KOH and after suitable purification steps, the liberated fatty acids were methylated using diazo methane and the resulting methyl esters were analysed by gas chromatograph fitted with FID. Results are presented in Table 6.27. The major fatty acids detected were palmitic (16:0) and oleic acid (18:1) in all the fractions of cashew apple pomace, neutral lipids fractions of cashew apple waste (ICAR Research Complex, Goa) and cashew apple powder. Fatty acids were not detected in the phospho lipid fraction of cashew apple waste (ICAR Research Complex, Goa). The ratio of unsaturated to saturated fatty acid in all the three fractions of cashew apple pomace, neutral lipid fraction of cashew apple waste (ICAR Research Complex for Goa), and neutral and glycolipid fraction of cashew apple powder ranged between 2.27 to 3.48 indicating the higher concentration of unsaturated fatty acids. Glycolipids (cashew apple waste) and phospholipids of cashew apple powder were rich in saturated fatty acids with unsaturated to saturated fatty acid ratio of 0.218 and 1.62 respectively.

#### **6.7.4 Conclusions**

Cashew apple powder could be prepared by sundrying for 5 days followed by drying in a cabinet dryer for 2 days at 70°C. Alternatively cashew apple powder could be prepared by autoclaving for 10 min at 16 PSI followed by drying in a cabinet dryer for 2 days at 70°C. The pectin isolated from cashew apple powder is a low methoxy pectin. Pectin could be isolated by acidic extraction followed by ethanol precipitation. The cashew apple pectin thus isolated contains very low ash which is desirable. However, as cashew apple pectin is low methoxy type, it may not be desirable as a gelling agent. The complex carbohydrate has been shown to contain more of insoluble fibre such as hemi cellulose A and B and cellulose compared to pectin which is a soluble crude fibre. Cashew apple powder lipids are rich in unsaturated fatty acids particularly oleic acid. It also contains poly unsaturated fatty acids which is having health benefit.

**Table 6.21: Composition of cashew apple powder (Sundried)**

Variety	Protein (mg/100 mg)	Starch (mg/100 mg)	Sugars (mg/100 mg)	IDB CA Powder (mg maltose released/ 3h /100 mg)	Peroxides (n moles MDA / 100 mg powder)
V-1	11.91	12.86	25.0	4.82	1.559
V-2	6.29	10.72	18.98	4.33	3.012
VRI-1	7.25	10.69	40.27	1.95	1.725
VRI-3	7.73	7.33	37.88	15.36	2.179
Chintamani-1	12.29	17.82	17.26	10.96	0.80
Jhargram-1	6.91	16.46	28.29	9.73	2.19
Goa-1	6.30	15.24	26.40	12.53	3.575
Bhubaneswar-1	7.07	8.95	27.99	17.21	ND
BPP-1	6.71	13.67	28.51	7.22	2.05
BPP-2	7.13	12.12	36.92	ND	ND
BPP-4	4.26	9.25	37.57	6.08	1.746
BPP-5	8.35	14.19	23.79	5.87	1.215
BPP-6	4.80	12.21	31.33	2.95	1.176
Ullal-1	8.34	11.87	30.47	3.35	1.713
Ullal-2	10.73	25.32	14.53	3.05	1.606
Ullal-3	9.12	13.95	27.15	2.75	1.417
Ullal-4	7.19	8.57	42.04	9.56	2.516
UN 50	9.20	14.47	19.84	4.44	1.228
BLA 39-4	10.27	28.66	17.22	5.97	0.772
Kanaka	8.05	17.91	13.79	6.73	1.577
K 22-1	9.47	16.02	20.29	10.32	1.555
Dhana	7.33	12.66	27.56	12.21	1.367
NDR 2-1	5.26	11.75	32.36	0.8	2.315
Priyanka	9.47	20.11	11.44	4.54	1.725
Sulabha	4.28	6.75	20.5	4.35	0.98
NRC Sel 1	7.59	9.53	33.35	11.01	1.981
NRC Sel 2	7.78	8.56	41.82	13.38	2.528
Bhaskara	9.20	8.24	15.75	3.16	1.343
Cashew apple powder (Yellow)	5.69	13.59	42.37	3.82	2.353
Cashew apple powder(Red )	5.48	15.53	34.12	11.56	2.513
Cashew apple powder,Bulk (Autoclaved and dried)	5.60	14.39	33.37	14.78	1.486
CD(5%)	0.9048	1.3232	6.1056	3.0647	0.6128
CV %	7.24	5.99	13.52	25.04	20.57

Values are mean of three individual estimations .ND-Not determined

**Table 6.22: Characterization of pectin.**

Source	Yield (%)	Ash (%)	Eq. wt.	Methoxyl content (%)	Acetyl content (%)
Cashew apple pomace	2.59	2.36	166.52	8.7	0.289
Cashew apple waste (ICAR Goa)	2.35	5.89	221.42	3.75	0.285
Cashew apple powder (Yellow) (Sun dried)	1.44	0.24	634.73	5.167	0.441
Cashew apple powder (Red) (sun dried)	2.25	0.25	691.68	3.34	0.539
Cashew apple powder (bulk) (autoclaved and dried)	1.84	1.18	384.17	5.08	0.512
Tight skinned orange peel	7.31	1.72	161.33	.08	0.167
Tight skinned orange pulp	10.11	3.12	157.69	4.53	0.166
Apple fruit powder	2.8	1.62	161.42	9.79	0.346
Lime fruit powder	4.58	2.41	121.70	3.85	0.291
Commercial sample	-	7.31	447.9	14.41	0.138
CD (5%)	-	0.866	102.6	3.71	0.109

**Table 6.23: Mineral composition of pectin ( $\mu\text{g}/\text{mg}$  pectin)**

Source	Ca	Mg	K	Na	Ca/Mg	Na/K
Cashew apple pomace	0.38	0.05	0.293	0.112	7.6	0.377
Cashew apple waste (ICAR Goa)	1.12	0.247	0.585	0.187	4.53	0.319
Cashew apple powder (Yellow) (Sun dried)	9.24	1.43	12.77	4.14	6.46	0.32
Cashew apple powder (Red) (sun dried)	11.58	1.74	16.85	3.97	6.65	0.23
Cashew apple powder (bulk) (autoclaved and dried)	23.31	5.79	22.83	5.48	4.02	0.24
Tight skinned orange peel	1.59	0.203	0.211	0.098	7.83	0.464
Tight skinned orange pulp	1.18	0.153	0.324	0.101	7.71	0.312
Apple fruit powder	0.63	0.103	0.549	0.071	6.12	0.129
Lime fruit powder	1.17	0.12	0.514	0.064	9.75	0.124
Commercial sample	0.41	0.177	0.344	0.114	2.32	0.114
CD (5%)	1.456	0.937	2.143	1.009		

Values are mean of three individual estimation

**Table 6.24: Extraction of pectin from cashew apple powder (Red, autoclaved and dried at 70°C for 2 days)**

Extract-ant	Yield (%)	Ash (%)	Purity (%)	Eq. weight	Methoxyl content (%)	Acetyl content (%)	Na	K	Ca	Mg
A	3.95	16.21	19.23	428.89	6.3	0.862	1.99	6.46	4.36	1.6
B	3.95	7.07	22.49	604.02	6.57	1.062	2.81	8.84	4.23	3.32
C	4.09	1.15	21.15	1279.35	5.04	1.084	6.13	65.25	50.33	19.43
D	1.88	2.68	25.61	1137.46	5.91	0.754	42.82	237.9	206.13	7.28
CD (5%)	1.527	1.274	2.635	105.04	2.088 (NS)	0.418 (NS)	6.645	4.08	23.342	3.443
SED	0.662	0.552	1.143	45.55	0.905	0.181	2.883	19.98	10.122	1.493

Values are mean of three individual estimation

**Table 6.25: Carbohydrate composition of cashew apple powder (g).**

	CA powder (Yellow)	Cashew apple powder (Red)	Cashew apple pomace
Weight of sample	50.13	50.00	50.02
Weight of sample after n-hexane and 80% ethanol extraction	25.14 (50.14)	18.33 (2.4)	38.25 (23.5)
Weight of cold water soluble fraction	0.4 (0.79)	0.12 (0.24)	0.69 (1.37)
Weight of hot water soluble fraction	0.44 (0.89)	0.23 (0.46)	0.53 (1.05)
Weight of pectin	2.6 (5.19)	0.89 (1.79)	2.08 (4.16)
Weight of cellulose	1.69 (3.38)	2.93 (5.86)	6.26 (12.51)
Weight of Hemi cellulose A	0.032 (0.06)	1.11 (2.22)	0.39 (0.78)
Weight of Hemi cellulose B	6.74 (13.44)	1.98 (3.96)	9.44 (8.87)

Figures within the paranthesis indicate % of sample taken for extraction

**Table 6.26: Lipid content of cashew apple powder**

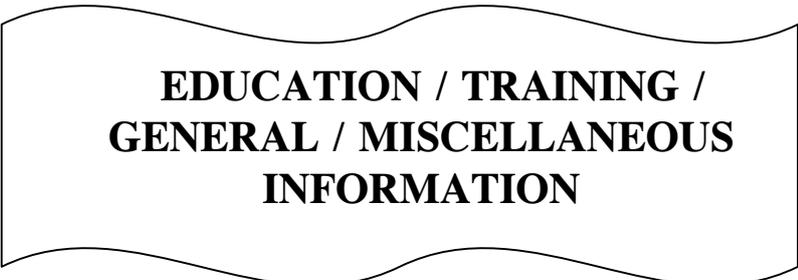
	% of total lipid			
	Total lipid (%)	NL	GL	PL
Cashew apple pomace	3.07	88.6	3.24	8.14
Cashew apple powder (Bulk)	0.94	28.46	70.27	1.27
Cashew apple waste (ICAR Res. Complex, Goa)	3.28	98.27	0.39	1.33
Cashew apple powder (Red)	2.89	46.96	21.61	31.43
Cashew apple powder (Yellow)	1.84	62.32	24.3	13.37
Cashew apple powder (Yellow, Salt KMS treated and autoclaved and dried)	1.46	64.97	23.44	1.49

NL – Neutral lipids, GL – Glycolipids, PL - Phospholipids

**Table 6.27: Fatty acid profile of different fraction of lipid.**

	Cashew apple pomace			Cashew apple waste (ICAR Res. Complex, Goa)			Cashew apple powder		
	NL	GL	PL	NL	GL	PL	NL	GL	PL
Fatty acid	0.41	-	0.19	2.07	-	-	-	-	-
C12:0	0.48	-	0.28	0.88	-	-	-	-	-
C14:0	19.12	23.17	19.15	19.11	6.28	-	23.75	-	-
C16:0	1.18	-	1.47	1.10	-	-	0.85	15.64	13.78
C16:1	1.52	2.30	2.10	2.50	0.92	-	0.45	2.28	8.95
C18:1	67.22	69.81	68.25	67.34	19.01	-	63.50	48.54	18.75
C18:2	1.85	2.36	2.06	1.97	-	-	1.68	3.70	7.96
C18:3	1.59	-	0.71	-	1.02	-	-	-	-
C20:0	3.29	2.35	3.04	2.83	0.94	-	2.63	3.91	8.66
C:220	2.52	-	0.95	0.99	0.83	-	1.09	1.67	6.69
C22:1	0.25	-	0.31	-	-	-	0.41	1.29	5.13
C24	0.56	-	1.23	1.19	68.54	-	1.32	10.3	3.84
Ratio of unsaturated / saturated	2.61	2.59	2.70	2.38	0.258	-	2.27	3.48	1.62

NL – Neutral lipids, GL – Glycolipids, PL - Phospholipids



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

## 7. EDUCATION AND TRAINING

- A special course on “Cashew Production Technology” was organized for the officials of Karnataka Cashew Development Corporation (KCDC) Ltd, Mangalore during 1-5 August 2006. A total of 30 officials were imparted training on improved cashew cultivation practices.
- Training on “Soft wood grafting techniques in cashew ” was organized during 22-23 , August, 2006 in which 12 trainees sponsored by Development Departments were trained on softwood grafting and nursery management. Similar training was also organized for Self-Help Groups of SKDRDP, Puttur on 26th September 2006.
- Three days refresher course on “Pruning in Cashew and Composting of Cashew Biomass” was organized during 14-16, December, 2006 during which 23 officials of Development Departments were imparted training on Canopy Management in Cashew and Composting of Cashew Biomass through Japanese and Vermicomposting methods.
- A refresher course on “Cashew Production Technology” was organized during 18-20 January, 2007 for the officials of Development Departments related to cashew. The purpose was to provide latest developments in cashew production technology to the officials. A total of nine officials representing four different Development Departments from Karnataka, Kerala and Andhra Pradesh were imparted training.
- A training programme on “Cashew apple utilization ” was organized for farm women in collaboration with Sri Kshethra Dharmasthala Rural Development Project (SKDRDP) , Puttur. The participants were imparted training on preparation various cashew apple products.

## 8. LINKAGES / COLLABORATION

Name of the organization	Type of collaboration
Central Food Technological Research Institute, Mysore	DBT Sponsored Project on nutraceuticals
PDBC, Bangalore	EAG and GCMS studies
SKDRDP, Dharmasthala Manaje Vyavasaya Sahakari Seva Society, Kamashile	Thematic campaigns, laying out demonstration plots, trainings 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

### Headquarters

The Director and Project Coordinator (Cashew), National Research Centre for Cashew, Puttur - 574202, DK, Karnataka.

Phone: 08251-231530 (O), 233490 (R ),230992 (R) EPBX :08251-230902, 236490

Fax: 08251-234350 ,231590

E-mail: [nrccaju@sancharnet.in](mailto:nrccaju@sancharnet.in), [nrccaju@rediffmail.com](mailto:nrccaju@rediffmail.com), [nrccaju86@yahoo.com](mailto:nrccaju86@yahoo.com)

Website: <http://www.nrccashew.org/index1.htm>

### University centres

1. Cashew Research Station, (Acharya NG Ranga Agricultural University), Bapatla 522 101, Guntur Dist., Guntur District ,Andhra Pradesh.  
Phone: 08643-225304  
E-mail : [sscrs@sancharnet.in](mailto:sscrs@sancharnet.in)
2. Cashew Research Station, Department of Horticulture, (Orissa University of Agriculture and Technology), Bhubaneswar 751 003, Orissa.  
Phone: 0674-2395383  
FaxNo.0674 - 2397780  
E-mail : [aicrpcashew\\_bbsr@yahoo.co.in](mailto:aicrpcashew_bbsr@yahoo.co.in)
3. Agricultural Research Station, (University of Agricultural Sciences), Chintamani 563 125, Kolar District, Karnataka.  
Phone : 08154-252118, 250420  
FaxNo 08154 -251046
4. S.G. College of Agriculture and Research Station, (Indira Gandhi Krishi Vishwa Vidyalaya), Jagdalpur 494 005, Kumharawand, Bastar District, Chhattisgarh  
Phone: 07782-229150, 229360  
FaxNo. 07782-229360  
E-mail : [zars\\_igau@rediffmail.com](mailto:zars_igau@rediffmail.com)
5. Regional Research Station, (Bidhan Chandra Krishi Viswa Vidyalaya), Jhargram Farm, PO Jhargram - 721 507, Midnapore (West) District, West Bengal.  
Phone: 03221-255593  
E-mail : [spcamit@rediffamil.com](mailto:spcamit@rediffamil.com), [schakraborti\\_ento@rediffmail.com](mailto:schakraborti_ento@rediffmail.com)
6. Cashew Research Station, (Kerala Agricultural University), Madakkathara 680651, Thrissur Dist., Kerala.  
Phone and Fax : 0487-2370339  
E-mail : [kaucaju@rediffmail.com](mailto:kaucaju@rediffmail.com)
7. Regional Agricultural Research Station, (Kerala Agricultural University), Pilicode 671 353, Kasaragod District, Kerala.  
Phone: 0467-2260632, 2260450  
Fax No. 0467-2260554  
E-mail: [adrrarspil@rediffmail.com](mailto:adrrarspil@rediffmail.com)
8. Regional Fruit Research Station, (Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth), Vengurle 416 516, Sindhudurg District, Maharashtra  
Telefax : 02366-262234, Phone :263275, 262693  
E-mail: [frs@sancharnet.in](mailto:frs@sancharnet.in)
9. Regional Research Station, (Tamil Nadu Agricultural University), Vridhachalam 606 001, Cuddalore District, Tamil Nadu.  
Phone: 04143-238231, 260412  
Fax.No. 04143-238120  
E-mail: [cdl\\_phrrsvri@sancharnet.in](mailto:cdl_phrrsvri@sancharnet.in)

## 10. PUBLICATIONS

### 10.1 Research Publication

Balsubramanian, D. 2006. Improving Whole Kernel recovery in processing – Specific to Cashew nuts of Nigeria origin. *Agricultural mechanization in Asia, Africa & Latin America* **37**(1):58-64.

Balasubramanian, D. 2006. Moisture Desorption Characteristics of Cashew kernels. *The Cashew*. **20**(1):13-19.

Bhat ,P.S. and Raviprasad ,T.N. 2006. Studies on endosulfan and carbaryl residues in cashew kernels. *J Plantn Crops*. **34**(3): 373-376.

Rejani, R and Yadukumar, N. 2006. Effect of soil and water conservation techniques for cashew garden grown on steep slopes. *J. Plantn. Crops*. **34** (3): 304-308.

Sundararaju, D. 2006. “Bhaskara”, a new cashew variety from NRCC, Puttur. *Cashew News* **11**(1) :2.

Sundararaju, D. 2006. The yield loss due to lepidopteran flower and fruit pests and their species composition. *Cashew News* **11**(2) :2

Sundararaju ,D. Raviprasad , T.N. Yadukumar, N., Bhat , P.S. and Venkattakumar, R. 2006 Performance of “Bhaskara” variety in different situations .*Cashew News* **11**(1): 2-3.

Sundararaju ,D. Yadukumar ,N. Bhat ,P.S. Raviprasd,T.N. , Venkattakumar , R. and Sreenath Dixit, 2006, Yield performanc of “ Bhaskara ” cashew variety in coastal Karnataka. *J Plantn. Crops*. **34**(3): 216-219.

Venkattakumar, R. 2006 Socio economic impact of cashew cultivation in Kannur district of Kerala. *J. Plantn Crops* **34**(3): 708-714.

Venkattakumar, R. and Nayak , M.G. 2005 Impact of Transfer of technology in cashew cultivation . *Manage Extension Research Review* .**6** (2): 53-57.

Yadukumar, N. and Balasimha, D. 2006. Effects of drip irrigation and fertilizer levels on photosynthesis in cashew. *Indian J .Hort*. **63**(3):310-315.

Yadukumar, N .and Rejani. 2006. Temporal and special variation of soil moisture content and development of a yield model based on soil moisture content for the cashew garden. *J. Plantation. Crops*. **34** (3): 364-367.

### 10.2 Popular Articles

Bhat M.G. Venkattakumar,R. 2006. Cashew Premier Position in World Market. The Hindu.Survey of Indian Agriculture. PP 203-207.

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

Balasubramanian, D. 2006. Post Harvest Technology of Cashew. **In:** training program on “ Post harvest Technology of Horticultural crops” conducted for trainees of Dept. of Agriculture, Govt. of Kerala by Division of Extension & Training, IHR, Hessaragatta, Bangalore.

Balasubramanian, D. 2006. Cashewnut processing in India – Its Opportunities and Challenges. **In:** State level seminar on Cashew, organized by Regional Research Station, Tamil Nadu Agricultural University, Vridhachalam, Tamilnadu.

Balasubramanian, D. 2007. Cashewnut processing in India – Opportunities and Challenges. **In:** The National Conference on Prospects and Challenges in Food Processing (NCP-2007) organized by Department of Food and Process Engineering, SRM University, Kattankulathur – 603 203, Kancheepuram district, Tamilnadu.

Balasubramanian, D. 2007. Processing aspects of Cashew. **In:** Cashew Seminar conducted by Dept. of Horticulture, Srikakulam district in collaboration with ITDC, Srikakulam and DCCD Cochin at Z P Conference Hall, Srikakulam, Andhra Pradesh.

Bhat, M.G., Nayak, M.G. and Nagaraja, K.V. 2006. Prospects of cashew in next decade with special reference to North Eastern States. **In:** National Workshop on Cashew organized by DCCD, Cochin. Jharnapani, Nagaland. 27<sup>th</sup> May 2006.

Bhat, M.G. 2007 Indian Cashew Scenario and Cashew Improvement. **In:** Cashew Seminar conducted by Dept. of Horticulture, Srikakulam district in collaboration with ITDC, Srikakulam and DCCD Cochin at Z P Conference Hall, Srikakulam, Andhra Pradesh on 29<sup>th</sup> January 2007.

Nayak, M.G. 2006. Potential demand from food processing, nutraceuticals, drugs and other sectors and its implications for conservation and characterization of cashew biodiversity. **In:** Workshop on Agrobiodiversity Conversation held at IIM (Ahmedabad) from 27-29 May 2006.

Yadukumar, N. 2006 Resource use efficiency in cashew. **In:** National Seminar on Resource use efficiency at CPCRI, Kasaragod , Kerala on 25<sup>th</sup> March 2005.

### 10.4 Book Chapters

Thimmappaiah , Shirly, R.A. and Iyer, R.D. 2007. Micropropagation of cashew *Anacardium occidentale* (L). **In:** Protocols for micropropagation of woody trees and fruits. Chapter 29 (Eds. Mohan Jain, S and Haggman,H) Springer Verlag, p-10.

### 10.5 Technical Reports / Bulletins / Compendia

All Indian Coordinated Research Project on Cashew. 2006. Annual Report 2005-06. NRC Cashew, Puttur, Karnataka 114 pp

National Research Centre for Cashew. 2006. Annual Report 2005-06, Puttur, Karnataka, 56 pp.

National Research Centre for Cashew. 2006. Cashew News, Newsletter. Vol. 11 (1), Jan-Jun 2006, Puttur, Karnataka. 8 pp.

National Research Centre for Cashew. 2006. Cashew News, Newsletter. Vol.11 (2), July – Dec. 2006, Puttur, Karnataka, 8 pp.

#### **10.6 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.

Nayak M.G. and Bhat P.S. 2007. “ Increasing cashew yield through adoption of soil and water conservation techniques, drip irrigation and organic farming”. Farmers’ View: Compilation during Annual Cashew Day, 28th March 2007 .4pp.

Yadukumar N. Nayak M.G.and Bhat P.S. 2007 Cashew Cultivation Practices (Kannada): National Research Centre for Cashew Extension Handout No.1 (Revised),6pp.

## 11. LIST OF ONGOING RESEARCH PROJECTS

	Project No.	Particulars
<b>I</b>	<b>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 (M. Gangadhara Nayak and MG Bhat)
	1.5	Micropropagation for clonal root stocks, somatic embryogenesis and rooting in cashew (Shirly R. Anil andThimmappaiah).
	Ad-hoc	Molecular characterization of cashew using RAPD and isozyme markers (Thimmappaiah )
<b>II</b>	<b>CROP MANAGEMENT</b>	
	2.2(b)	Fertilizer application and pruning trials in high density plantations (N .Yadukumar).
	2.3	Canopy management studies in cashew (MG Nayak and N. Yadukumar ).
	2.8	Efficacy of soil and water conservation with organic and inorganic manuring in cashew garden grown in slope areas (N .Yadukumar and R. Rejani).
	2.11	Performance of high yielding varieties of cashew in different high density planting (N.Yadukumar and M. G. Nayak).
	2.12	Rejuvenation of trees of high density cashew orchards through canopy management (N.Yadukumar and M. G. Nayak).
	Observational trial	Green manuring in cashew to increase productivity of cashew (N. Yadukumar and R .Rejani).
<b>III</b>	<b>CROP PROTECTION</b>	
	3.6	Studies on determination of insecticide residues in cashew kernels (P.S. Bhat and T.N .Raviprasad).
	3.7	Studies on pheromones of tea mosquito bug <i>Helopeltis antonii</i> S. (P.S. Bhat and T.N. Raviprasad).
	3.8	Integrated pest management of cashew stem and root borer (CSRB) – Phase-II (T.N .Raviprasad and P.S. Bhat).
	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).
	Paid up Trial	Evaluation of newer insecticides against tea mosquito bug <i>Helopeltis antonii</i> Sig (P.S.Bhat).
<b>IV</b>	<b>POST HARVEST TECHNOLOGY</b>	
	4.7	Developing economically viable on- farm cashew nut processing (D. Balasubramanian).

	Observational trials	Development of drying system suitable for raw cashew nuts (D. Balasubramanian).
		Design and development of high calorific fuel briquette using cashew nut shell cake (D. Balasubramanian).
		Development of solar dryer for drying cashew apple (D. Balasubramanian).
	4.9	Studies on preparation of nutraceuticals from cashew apple (K.V. Nagaraja). [Concluded in March 2007]
	DBT	Nutraceuticals for healthy and speciality foods through biotechnology approaches (K.V .Nagaraja).
<b>V</b>	<b>TRANSFER OF TECHNOLOGY</b>	
	5.1	Transfer of technology programme in cashew (R. Venkattakumar, N.Yadukumar P.S. Bhat and M.G. Nayak)
	5.3	Socio - economic impact of cashew cultivation – An analysis (R .Venkattakumar, T.N. Raviprasad and M.G. Nayak )
	5.4	Impact of cashew nut production technology on increase in area and productivity of cashew (R .Venkattakumar) .

## 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 4th 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 second meeting of the fourth RAC (11th meeting) of the Centre was held on 25th and 26th May 2007 under the Chairmanship of Dr. M.K.Nair , Former Director CPCRI, Kasaragod. Drs. K.V. Ramana, ADG(PC), D.P.Ray, G. Gajendran , A.G. Appu Rao and P.M. Haldankar 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	Tenure
Dr. MG Bhat, Director, NRCC, Puttur, - 574202, DK District, Karnataka. Ph: 08251-231530,230902	Chairman	Three years from 28-11-2006
Dr. K.V.Ramana Assistant Director General (Hort-II),ICAR, Krishi Anusandhan Bhavan-II, New Delhi-110 012 Mobile:09868627903, 011-25848029( O) 011-25841284 Extn 1415	Member	Three years from 29-12-2006
The Joint Director of Horticulture,(Plantation Crops & Plant Protection) ,Lalbagh, Bangalore-560 004, Karnataka	Member	Three years from 28-11-2006
Dr. S. Rajan , Associate Director of Research, Kerala Agricultural University, Vellanikara, Thrissur, Kerala -680 656.( Representing Dept. of Agriculture, Govt. of Kerala)	Member	Three years from 28-11-2006
Dr. J. Venkatesha, Director of Instruction (Hort), Horticulture College, Mudigere -577 132, Chickmagalore, District. Karnataka	Member	Three years from 28-11-2006
Senior Finance & Accounts Officer, Central Plantation Crops Research Institute, Kudlu Kasaragodu- 671 124 , Kerala .	Member	Three years from 28-11-2006
Dr. D. Balasimha, Head, CPCRI Regional Station, Vittal-574243, DK	Member	Three years from 29-12-2006
Dr. K.V.Nagaraja, Principal Scientist (Biochemistry), NRCC, Puttur - 574202, DK District, Karnataka Ph: 08251-230902	Member	Three years from 29-12-2006
Dr. Thimmappiah, Principal Scientist ( Genetics & Cytogenetics), NRCC,Puttur . - 574202, DK District, Karnataka Ph: 08251-230902	Member	Three years from 29-12-2006
Dr. (Mrs.) R. Rejani Scientist (Soil & Water conservation Engineering), NRCC,Puttur- 574202, DK District, Karnataka Ph: 08251-230902	Member	Three years from 29-12-2006

The Institute Management Committee met twice on (30.8.2006 and 26.03.2007) 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 X Plan period were finalized during the meetings.

### 12.3 Institute Research Committee (IRC) Meeting

The nineteenth Institute Research Committee (IRC) was held on 7<sup>th</sup> and 8<sup>th</sup> June 2006. In the introductory remarks, Dr. M.G. Bhat, Director, NRC Cashew and Chairman of the SRC meeting briefed about the progress made in different research projects and the contemplated research programmes. There were different technical sessions – “Crop Improvement” chaired by Dr. R.V. Nair, Head, Crop Improvement Division, CPCRI, Kasaragod; “Crop Management” chaired by Dr. George V. Thomas, Director, CPCRI, Kasaragod; “Crop Protection” chaired by Dr. D. Rajagopal, Retired DI(PGS), UAS, Bangalore; “Post Harvest Technology” chaired by Dr. K.V. Kasturibai, Head, Division of Physiology, Biochemistry and Post Harvest Technology, CPCRI, Kasaragod and “Transfer of Technology” chaired by Mr. Venkatesh N. Hubballi, Director (i/c), DCCD, Kochi. The scientists of the centre presented progress made under various projects (19). Three new projects were approved during the meeting.

### 12.4 Institute Joint Staff Council (IJSC)

Official Side	
Dr. M.G. Bhat	Chairman
Dr. K.V. Nagaraja	Member
Dr. P.S. Bhat	Member
Shri. K. Sanjeeva	Member
Shri. H. Ganesh	Member
Dr. R. Venkattakumar	Secretary
Staff Side	
Shri. K.V. Ramesh Babu	Member (CJSC)
Shri. Lakshmi pathi	Member-Secretary
Shri. K.M. Lingaraja	Member
Shri. K. Balappa Gowda	Member
Shri. S. Ammu Gowda	Member
Shri. K. Narayana	Member

The IJC met 4 times at quarterly intervals during the year to discuss about staff welfare activities

### 12.5 RAJBASHA

(Enclosed)

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

M.G.Bhat	National Seminar / Workshop on Cashew organized by Central Institute of Horticulture, Medziphema, Nagaland and Directorate of Cashewnut & Cocoa Development, Kochi at Jharnapani, Medziphema, Nagaland.	27-28 May 2006
M.G.Nayak	Seminar on Agro-biodiversity conservation at Indian Institute of Management, Ahmedabad	27-29 May 2006
M.G.Bhat	Meeting of Mega Seed Project – “Seed Production in Agricultural Crops and Fisheries” at NAAS Auditorium, NASC Complex, New Delhi.	27- 28 June 2006
Balasubramanian, D	Training program on “ Post harvest Technology of Horticultural crops” conducted by Division of Extension & Training, IIHR, Hessaragatta, Bangalore.	10 July 2006
M.G.Bhat	Meeting of Working Group on Horticulture, Plantation Crops, Organic Farming including Sub-Group on Horticulture and Plantation Crops for formulation of the XI Five Year Plan in Yojana Bhavan, New Delhi.	28 July 2006
D.Sundararaju	Third Review Meeting of the ICAR adhoc scheme, “Forewarning Tea Mosquito Bug ( <i>Helopeltis antonii</i> ) in Cashew” at RARS, KAU, Pilicode, Kerala.	19 August 2006
M.G.Bhat	First Meeting of Sub-Group on Fruits and Plantation Crops as its Member Secretary at Rajendra Agricultural University, Pusa, Samastipur, Bihar for formulation of XI Five Year Plan.	25-26 August 2006
M.G.Nayak	National Seminar on input use efficiency at Bangalore.	9-11 September 2006
M.G.Bhat	Special Training Programme on “Vigilance Administration and Management” for Directors / Project Directors of all Research Institute / PDs / NRCs located in the State of Andhra Praesh, Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu at NAARM, Hyderabad.	18 - 20 September 2006
M.G.Bhat	Second Meeting of Sub-Group on Fruits and Plantation Crops as its Member Secretary at Indian Agricultural Research Institute, Pusa, New Delhi for formulation of XI Five Year Plan.	14-15 September 2006
M.G.Bhat	Third and Final Meeting of Sub-Group on Fruits and Plantation Crops as its Member Secretary at Horticulture Information Centre Hall of Directorate of Horticulture, Lal Bagh, Bangalore for formulation of XI Five Year Plan.	19 October 2006
M.G. Bhat	ICAR Directors Conference at NAAS Symposium Hall, NASC complex, New Delhi	3-4 November 2006

P.S.Bhat T.N.Raviprasad	Research Extension Interface 2006, Arranged by Department of Agriculture, Government of Kerala, Kasaragod.	18 November 2006
K.V.Nagaraja N.Yadukumar P.S.Bhat T.N.Raviprasad	State level Cashew Development Workshop (Production, Processing and marketing) held at Regional Agricultural Research Station , Pelicode, Kerala.	28 November 2006
N.Yadukumar T.N.Raviprasad	Regional seminar on application of radio isotopes and radiation technology organized by Mangalore University and BARC, Mumbai at Mangalore.	29-30 November 2006
M.G.Bhat K.V.Nagaraja N.Yadukumar D.Sundararaju P.S.Bhat R.Rejani	Plantation Crops Symposium XVII (PLACROSYM XVII) held at Hotel Presidency, Kochi .	5-8 December 2006
Balasubramanian, D	State level seminar on Cashew organized by Regional Research Station, Vridhachalam, Tamil Nadu Agricultural University, Tamilnadu.	December 22, 2006
Balasubramanian, D	National Conference on Prospects and Challenges in Food Processing (NCPCFP-2007) organized by Department of Food and Process Engineering, SRM University, Kattankulathur – 603 203, Kancheepuram district, Tamilnadu.	January 24, 2007
M.G.Bhat Balasubramanian, D	Seminar on cashew conducted by Dept. of Horticulture, Srikakulam district in collaboration with ITDC, Srikakulam and DCCD Cochin at Z P Conference Hall, Srikakulam, Andhra Pradesh.	January 28-29, 2007
D.Sundararaju	National Science Day St.Philomina College, Puttur with inaugural address.	28 February 2007
M.G.Bhat M.G.Nayak	Meeting of Mega Seed Project “Seed Production in Agricultural Crops and Fisheries”, NASC, New Delhi.	1-2 March 2007

## 14. FARMERS DAY/KRISHIMELA/EXHIBITION/CAMPAIGNS

N.Yadukumar M.G.Nayak P.S.Bhat R.Venkattakumar	Visit to different cashew growing areas of Andhra Pradesh to study conditions of cashew plantations in Andhra Pradesh.	April 2006
M.G.Bhat P.S.Bhat	Seminar on cashew arranged by Department of Horticulture ; Farm Exchange Club , Moodabidri and SKDRDP , Dharmasthala at Moodabidri, DK district, Karnataka	9 June 2006
M.G.Nayak	Campaign on cashew cultivation at Kodiyadi village near Puttur	23 June 2006
M.G.Nayak	Campaign on cashew cultivation at Savnoor	14 July 2006
T.N. Raviprasad	Cashew seminar organized by Nagarika Seva Samithi in collaboration with Department of Horticulture at Guruvayanakere.	7 November 2006
P.S.Bhat T.N.Raviprasad R.Venkattakumar	A training programme/campaign on plant protection in cashew organized at Bareppady, Near Savanoor, Puttur	27 November 2006
M.G.Nayak P.S.Bhat	Exhibition arranged at Kolthige, Puttur taluk in connection with the Golden Jubilee celebration of Higher Primary School, Kolthige.	2 February 2007
T.N. Raviprasad	Farmers meet organized by Department of Horticulture, Karnataka at Hiriyangadi	12 March 2007
M.G. Bhat D. Sundararaju T.N. Raviprasad	Cashew Day at Agricultural Research Station, (UAS), Ullal, Mangalore.	24 March 2007
All Scientists, technical and administrative staff	Annual Cashew Day at NRCC, Puttur	28 March 2007

## 15. DELEGATION / TRAINING

Balasubramanian, D	Refresher course on “ Computer based Multimedia Training Program” at NAARM, Hyderabad	14 July – 3 August 2006
M.G. Bhat	Special Training Programme on “Vigilance Administration and Management at NAARM, Hyderabad	18-20 September 2006
N. Yadukumar Balasubramanian, D	Visit to Central Institute of Cotton Research, Nagpur, Maharashtra to study “Zero Maintenance for Institute building”	21-22 September 2006
R.Rejani	Refresher course on “ Information technology in agriculture for effective decision support” at NAARM , Hyderabad.	4 –24 October 2006
Balasubramanian, D	CAS training program on “ Design & Development of Web based Application using NET technology” conducted at Indian Agricultural Statistical Research Institute (IASRI), New Delhi	2 November – 12 December 2006

Balasubramanian, D	Training on “ Cashew Apple Utilisation” at CRS Maddakkathara, Thrissur, Kerala	5-6 March 2007
N.Yadukumar	Spot course on advanced Irrigation systems for intensive crop production at IARI, New Delhi	15 – 25 March 2007

## 16. Radio talk/ Interview / Video Programmes

### 16.1 TV Progrmme/Interview

D.Balasubramanian	Video clip on “Small scale Cashewnut processing” in Doordarshan, Karnataka (Chandhana TV)	March 2007
N.Yadukuamr	TV programme on soil and water conservation and intercropping in cashew ” in Doordarshan, Karnataka (Chandhana TV)	March 2007

### 17.2 Radio talk/ Interview (AIR, Mangalore)

P.S.Bhat	Tea mosquito bug menace and management	6 April 2006
T.N.Raviprasad	Cashew stem borer menace and management.	12 April 2006
M.G. Nayak	Vegetative Propagation and nursery management in cashew.	May 2006
P.S. Bhat	Pest control in cashew crop.	26 August 2006
M.G. Nayak	Training and pruning in cashew.	August 2006

## 17. Distinguished visitors

Dr. S.P. Ghosh Retired Deputy Director of General (Horticulture) ICAR, New Delhi.	05 May 2006
Dr. G. Kalloo Deputy Director General (Hort) ICAR, New Delhi	15 June 2006
Sri G.K. Naidu, IMC Member Kacharavedu Village, Alapakam Post, Nindra mandal, Chittoor District, Andhra Pradesh	30-31 August 2006
Sri. Maheshwar Rao Deputy Commissioner Mangalore.	16 March 2007

## 18. PERSONNEL

### Managerial

Director Dr. M.G. Bhat

### 18.1 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	R. Venkattakumar (up to 23-12-2006)	--	--	1(1)
Biochemistry (Pl.Sci.)	--	--		KV Nagaraja	1
Biotechnology	--	--	--	Thimmappaiah (Gen. & Cyto.)	1
Computer Application	PD.Srekanth *	--	--	--	1
Genetics and Cytogenetics	Vacant		Vacant	--	2(2)
Horticulture	Vacant	--	J.D. Adiga(w.e.f. 5-2-2007) 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	6(4)	1	5(2)	6(1)	18 (7)

\* On study leave for Ph.D.

Figures in the parantheses indicate no. of vacant posts.

## **18.2 . Technical**

Sri.K.Muralikrishna	Farm Superintendent T(7-8)
Sri. P. Adbulla	Farm Superintendent T (7-8)w.e.f. 21-07-2004
Sri.A.Padmanabha Hebbar	Tech. Officer (Elec.) (T-5)
Sri.R.Arulmony	Tech. Officer (lib.) (T-6 )
Sri.Prakash G Bhat	Tech. Officer (T-6)
Sri.N.Manikandan	Technical Officer (T-5)
Sri. R. Muthuraju	Techncial Officer (Computer) (T-5)
Sri. K. Seetharama	Technical Officer (T-5) (Farm)

Sri. Lakshmipathi, Sri. R. Lakshmisha and Sri. K.V. Ramesh Babu **(T-4)**; Sri.K. R.Padmanabhan Nair (up to 31-1-2007), A. Poovappa Gowda and Sri. B. Prabhakara **(T-3)**; Ravishankar Prasad, K. Babu Poojary, Sri. Bejmi Veigus, Sri. K.K. Madhavan and Sri. K. Umanath **(T-2)**.

## **18.3. 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)

## **19. MISCELLANEOUS**

### **19.1 Planting material production and distribution**

A total of 1,58,870 (50,075 from Kemminje and 99,795 from Shantigodu nurseries) cashew grafts were produced and distributed to farmers and development departments.

### **19.2 Posting nursery information on NRCC, Website**

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

### **19.3 Visitors**

More than 500 visitors viz., farmers, development department officials were provided orientation about the research and development activities of NRCC, Puttur.

#### 19.4 Inauguration of Library cum Conference Hall Complex

Dr. G. Kalloo, Deputy Director General (Hort), ICAR, New Delhi inaugurated the newly built Library cum Conference Hall Complex at NRC-Cashew on 15<sup>th</sup> June 2006.

#### 19.5 Exhibition

Scientists of NRC Cashew participated in an exhibition “ Hasirusiri” organized by Dakshina Kannada Zilla Panchayat Higher Primary School , Kolthige at Kolthige (Puttur taluk) on 2.2.2007 in connection with “Golden Jubilee Celebrations”. The latest technologies were explained through posters and specimens to nearly 1000 farmers who took part in the exhibition.

#### 19.6 Weather data (2006-2007)

Month	Temperature (°C)		Humidity (%)		Rainy days	Rainfall (mm)	Sunshine hours	Evaporation
	Max	Min	FN	AN				
Apr.06	36.8	39.4	88	46	1	52.20	5.4	5.0
May 06	32.9	23.4	93	67	12	704.60	4.4	3.6
Jun. 06	30.7	22.5	95	77	19	762.70	3.4	3.0
Jul. 06	29.2	22.9	96	84	33	1126.20	0.7	2.3
Jul. 06	30.5	22.8	94	75	18	286.80	1.3	2.6
Aug. 06	30.0	22.7	95	74	13	354.30	1.9	2.0
Sept. 06	25.4	17.8	75	53	17	416.20	1.9	2.0
Oct. 06	33.0	21.8	93	59	5	81.60	2.4	2.8
Nov. 06	33.3	17.3	90	43	0	0.00	5.5	3.2
Dec. 06	34.5	17.1	95	51	0	0.00	5.9	3.7
Jan. 07	34.9	18.4	93	45	0	0.00	9.6	4.3
Feb. 07	36.2	22.3	92	45	0	0.00	6.0	4.6
Mar.07	36.8	39.4	88	46	1	52.20	5.4	5.0

### 19.7. 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	Cashew Nutritive Value (Brochure)	
12	Database on cashewnut processing in India (2003)	100.00
13	Directory of cashewnut processing industries in India (2003)	100.00
14	Process catalogue on development of economically viable on-farm cashewnut processing	Priced
15	Cashew cultivation practices (Pamphlet)	

Address your enquiries to the Director, NRCC, Puttur – 574 202, D.K., Karnataka  
Price indicated above does not include postage