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

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Annual Report 2001-2002, Puttur, Karnataka

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भूमिका

इस केंद्र में अप्रैल 2001 से मार्च 2002 तक किया गया कार्यविधि के बारे में वार्षिक प्रतिवेदन 2001-2002 को प्रस्तुत करने में मुझे बहुत प्रसन्नता है। इस कालावधि में फसल सुधार, फसल प्रबंन्ध, फसल संरक्षण, कटाई उपरान्त प्रौध्योगिकी व तकनीकी हस्तांतरण का विभिन्न क्षेत्रों में महत्वपूर्ण कदम हासिल किए हैं।

बापट्ला, भुबनेश्वर, चिंतामणि, झारग्रां, माडकत्तरा, पिलिकोड, वेंगुर्ले और वृद्धाचलं में स्थित अखिल भारतीय समन्वित काजू अनुसंधान परियोजना के आठ स्थानीय काजू जीनबैंक में और राष्ट्रीय काजू जीन बैंक, रा.का. अनु. कें., पुत्तूर में संरक्षित 1125 काजू एक्सेशनूस की जिलावार संचयन नक्शा बनाने में इस केंद्र प्रमुख भूमिका निभाया है। तथानुसार, "भारत में काजू जननद्रव्य संचयन का स्थिति" नामक एक तकनीकी बुलेटिन प्रकाशित किया गया है।

बागवानी विभाग, यू.ए.एस. बेंगलूर तथा डी.एन.ए. "फिंगर प्रिंटिंग" का राष्ट्रीय अनुसंधान केंद्र, नई दिल्ली की सहयोग में चल रहें काजू जननद्रव्य का आण्विक चरित्रवर्णन प्रयोग संबंध में रा.का.अनु.कें., पुत्तूर में ही, काजू पत्तों से डी.एन.ए. निष्करण विधि मानकीकृत किया गया है। रा.का. जीन बैंक में संरक्षित सभी काजू एक्सेशनूस के आण्विक चरित्रवर्गन करने की कोशिश की जाएगी।

वर्तमान हालत में जैविक कृषि की प्रानुख्यता को समझते हुए, काजू बागों में पुनश्चक्रयोग्य जैवमात्रा का उपयोग के बारे में अध्ययन प्रारंभ किया गया है। इससे पता चला की पौषणयुक्त कांपोस्ट तथा वर्मीकाम्पोस्ट सरल विधियों से तैयार कर सकते हैं।

जैविक नियंत्रण परियोजना निदेशालय के सहयोग में किए गये प्रयोग से काजू काण्ड और जड़ छेदक के आकर्षकों के बारे में आशाजनक संकेत मिला है। वयस्क काजू काण्ड और जड़ छेदक भृंगो को आकर्षित करने हेतु क्षेत्रीय परिस्थितियों में आकर्षण फंदा विकसन करने की कोशिशों को जोर दिया जाएगा।

तकनीकी हस्तांतरण में क्षिप्रता लाने के लिए इस केन्द्र ने डी.सी.सी.डी. कोच्ची, एस. के.डी. आर. डी.पी. धर्मस्थला तथा काजू उगानेवालें राज्यों के विकास विभागों के साथ सहयोग जारी रखा है। कृषकों और विकास विभागों को एक लाख से ज्यादा उत्कृष्ट कलमनों को उत्पन्न तथा उपलब्ध करके केंद्र ने अपना प्रतिष्ठा खायं रखा है।

हमारे देश में कच्चा काजू गुटली उत्पादन का अन्दाजा करने के लिए कोई क्रमबद्ध फसल पैदावार विश्लेषण उपलब्ध नहीं है। व्यवस्थित क्षेत्र में होनेवाली गुटली संशोधन तथा व्यापारी ऑखडें पर ही कारखाना अन्दाज़ा निर्भर है। अनुसंधान व विकास विभागों का अन्दाज़ा तथा कारखाना अन्दाजों में अन्तर के लिए, शायद यह कारण हो सकता है। पैदावार अन्दाजा की "मॉडल" बनाने के लिए रा.का. अनु.कें. में अध्ययन शुरू किया गया है और इन मॉडल के आधार पर उचित रूप से पैदावार अन्दाज़ा लगा सकते हैं।

अलग अलग परियोजना में तकनीकी कार्यक्रम की यशस्वी कार्यान्वयन में सहकर्मियों का परिश्रम इस वार्षिक प्रतिवेदन में मूर्तरूपित है। हमारा अनुसंधान कार्यक्रमों का सुधारण हेतु मैं आदरणीय वाचकगण से सुझाव और अलोचना स्वागत करता हूँ। इससे हमें अन्य काजू उत्पादक देशों से, बढ़ती हुई जागतिक स्पर्धा की चुनौतीयों को सामने करने में आसानी होगी। दसवीं योजना की अंत तक दस लाख मेट्रिक टन कच्चा काजू का उपज बढ़ाने का तुरंत अवश्यकता है और इसलिए योजना बनाने में सुझावों सहकारी होगी।

केंद्र के इस साल के निष्पादनों के संकलन के लिए मै संपादकीय समिति को आभार हूँ।

ई वी वी भास्कर राव

(ई.वी.वी. भास्कर राव)
निदेशक

एन.आर.सी.सी., पुत्तूर
23, अगोस्त, 2002

PREFACE

I am pleased to present the Annual Report 2001-2002 of National Research Centre for Cashew in wh activities of the centre for the period from April 2001 to March 2002 are covered. During the period, the cen has made significant strides in the implementation of diverse activities contemplated under Crop Improveme Crop Management, Crop Protection, Post-Harvest Technology and Transfer of Technology aspects.

The centre has taken a lead in preparing district - wise collection maps for 1125 cashew accessions wh are conserved in NCGB at NRCC, Puttur and eight RCGBs at AICRP on cashew centres at Bapatla, Bhubanesw Chintamani. Jhargram, Madakkathara, Pilicode, Vengurle and Vridhachalam. Accordingly, a technical bulle entitled "Status of cashew germplasm collection in India" has been published.

In continuation of collaboration with Division of Horticulture, UAS, Bangalore and NRC on DNA Fing Printing, New Delhi for molecular characterization of cashew germplasm accessions, procedures have bee standardized for the extraction of DNA from cashew leaves at NRCC, Puttur itself. Further, efforts will be mad for molecular characterization of all the accessions conserved in NCGB at Puttur.

Realising the importance of organic farming in the present scenario, studies have been initiated for utilizatic of recyclable bio-mass in cashew orchard. The results have shown that nutrient rich compost and vermicompo can be prepared by following simple procedures.

Studies undertaken in collaboration with PDBC, Bangalore have given promising clues regarding kairomon attracting CSRB adults. Efforts will be intensified for the development of kairomone traps under field conditio for attracting adult CSRB beetles.

The centre continued its collaboration with DCCD, Kochi, SKDRDP, Dharmasthala and Developm Departments of cashew growing states for speedy transfer of technologies on cashew. The centre has also k up its reputation by producing and supplying over one lakh of quality cashew grafts to farmers and Developm Departments.

There is no systematic crop analysis for the estimation of raw cashew nut production in the coun Mostly industry's estimate is based on the nut processed by the organized sector and trade figures. This could possibly one of the reasons for variation in production estimates of Research and Development Department one side and industry on the other. Studies have been initiated at NRCC for the development of yield forecast models for different states and based on the model developed, it is possible to forecast yield with fair degre accuracy.

This Annual Report embodies the efforts of my colleagues in successful implementation of the techni programme in different projects. I welcome the suggestions and criticism from the esteemed readers for improv our research efforts. This will help us to face the challenges amidst growing global competition from ot cashew growing countries. There is immediate need to increase production of raw cashew nuts to 10 lakh by the end of X plan and the strategies can be formulated based on the suggestions.

I am grateful to the Editorial Committee for compilation of achievements of the Centre during the ye

EVV Bhaskara Rao

Place : NRCC, Puttur
Date : 23 August 2002

(EVV. BHASKARA RAO)
Director

EXECUTIVE SUMMARY

National Research Centre for Cashew was established in 1986 to increase production and productivity of cashew. The mandate of the research centre includes evolving high yielding varieties with desirable quality parameters, standardization of agro-techniques and transfer of proven technologies. A total of 22 research projects including three ad-hoc schemes of ICAR, one DBT scheme and one NATP project were in operation to achieve the mandate of the centre. These projects were under the areas of Crop Improvement (6), Crop Management (6), Crop Protection (4), Post-Harvest Technology (3), Transfer of Technology (2) and Statistics (1). The highlights of the various projects are summarized below.

During the planting season, 18 clonal accessions collected from Andhra Pradesh, Karnataka, Kerala and Maharashtra were planted in NCGB bringing the total number of accessions planted so far to 451. After completion of six harvests, fourteen accessions in NCGB were evaluated and characterized during the year as per IPGRI cashew descriptors taking the accessions characterized so far to 269. IC numbers have been assigned by NBPGR, New Delhi for the accessions conserved in NCGB at Puttur and Regional Cashew Gene Banks at AICRP on Cashew Centres. Studies on micropropagation were continued during the year. Axillary shoot bud proliferation (1-2 buds/explant) was induced on MS medium containing thidiazuron from shoot explants of matured tree origin. Micrografting was successful even with microscions of less than 5 mm length. On medium containing 2,4-D and Kinetin, low frequency somatic embryogenesis was observed on callus from nucellus. Suspension culture from embryogenic calli resulted in high frequency regeneration of somatic embryos.

Thrust was given to understand growth and yield of cashew under both pruned and unpruned conditions. The cumulative yield (5th to 10th year) in plot with 500 trees/ha was 2.38 and 1.98 times that of plots with 156 trees/ha under pruned and unpruned conditions respectively. Recyclable bio-mass from cashew garden after mixing with cow dung slurry (15% of total weight) could be converted into vermicompost by earthworm *Eudrilus* sp within three months. This vermicompost is rich in N, P, K and micronutrients.

The collaboration with PDBC, Bangalore has been strengthened to identify the kairomones, which attract cashew stem and root borer (CSRB). Th Electroantennogram studies showed that unmate males and virgin females showed higher response t extracts and volatiles collected from cashew bark, fras and exuded gum. Against tea mosquito bug (TMB) λ-cyhalothrin was effective under field conditions an was comparable with carbaryl (0.1%). The extent o egg parasitisation by *Telenomus* sp. was positively related to host egg density and negatively related t maximum temperature. Residues of lindane an endosulfan used for the management of CSRB and TM respectively were not detected in raw nuts collecte from farmers' plots in Dakshina Kannada district.

Cashew kernel baby bits coated with sugar and different flavours (vanillin, cardamom, ginger and clove) could be stored without any quality deterioration upto eight months. Cardamom flavoured saffron coloured baby bits were preferred most by the panel of judges. Cashew apple pomace carbohydrate could not be digested by diastase. It indicated that carbohydrate component in pomace is indigestible. Cashew apple pomace could be blended with cereals and pulses upto 10% without affecting quality.

A single operation CAM type pedal operated cashewnut sheller has been developed to overcome the drudgery experienced in the presently used hand cum pedal operated sheller.

For estimation of cashew yield, forecasting models have been worked out for India as well as for different cashew growing states in the country.

Eight model cashew clonal gardens under high density system of planting have been established during the year bringing the total number of demonstration plots laid out so far to 89. Overwhelming response was seen for campaigns on soil and water conservation and plant protection in cashew conducted in collaboration with Sri Kshethra Dharmasthala Rural Development Project (SKDRDP) at four locations in which nearly 450 farmers participated. Training programmes on cashew production technology were conducted for three batches of trainees apart from training programme on vegetative propagation of cashew. Annual cashew day was organized to educate the farmers about the latest technologies of cashew cultivation at Experimental Station, Shantigodu in which more than 120 farmers from 20 villages participated.

INTRODUCTION

Research on cashew was first initiated in the early 1950 by Indian Council of Agricultural Research by sanctioning ad-hoc schemes for Research Centres located at Kottarakkara (Kerala), Ullal (Karnataka), Bapatla (Andhra Pradesh), Daregaon (Assam) and Vengurle (Maharashtra). Cashew research received further impetus with the establishment of Central Plantation Crops Research Institute (CPCRI) at Kasaragod, Kerala. Cashew was included as one of the mandate crops of CPCRI. Simultaneously, ICAR also sanctioned All India Coordinated Spices and Cashew Improvement Project (AICS and CIP) for CPCRI, Kasaragod. The CPCRI Regional Station, Vittal (Karnataka) was given the mandate to work on cashew while four University Centres (Baptala, Vridhachalam, Anakkayam and Vengurle) were assigned the research component on cashew under AICS and CIP. During the V and VI plan three more centres (Bhubaneswar, Jhargram and Chintamani) came under the fold of AICS and CIP.

Efforts on cashew research were further strengthened by the implementation of World Bank aided Multi State Cashew Project (MSCP) with research component in Kerala, Karnataka, Andhra Pradesh and Orissa from 1982 to 1986. The Quinquennial Review Team (QRT) constituted by ICAR in 1982, after reviewing the entire research work on cashew recommended delinking of cashew and spices research from CPCRI and establishing two independent National Research Centres one each on cashew and spices at Puttur, Karnataka and Calicut, Kerala respectively. 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 made similar recommendations at the same time. This laid the foundation for establishment of National Research Centre for Cashew at Puttur on 18th June 1986. Subsequent to bifurcation of AICS and CIP, the headquarters of All India Coordinated Research Project on Cashew was shifted to NRC for Cashew, Puttur. The Cashew Seed Farm at Shantigodu which was started by CPCRI in 1972 was transferred to NRC for Cashew which now forms the Experimental Station of NRCC.

MANDATE

National Research Centre for Cashew i conceived to undertake mission oriented researc projects with the mandate of evolving high yieldin varieties of cashew with resistance / tolerance to pes such as tea mosquito bug, high protein, lysine an other desirable parameters; standardisation o agrotechniques for achieving higher production an productivity with sustainability in view, and transfe of technology to farmers and extension agencies o improved production techniques through training demonstrations and extension literature.

As Director of National Research Centre fo Cashew also monitors AICRP on Cashew, Mandate for cashew research as a whole under National Research Centre for Cashew and All India Coordinated Research Project on Cashew is reoriented.

- 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 a centre for training in research methodologies and technology updating of cashew and to coordinate nationa research projects.
- To provide consultancy regarding cashev production technology.
- To generate quality planting material.
- To collaborate with national an international agencies for achieving th mandate.

ORGANIZATIONAL SET UP AND INFRASTRUCTURE

Headquarters

National Research Centre for Cashew is locate with its headquarters at Puttur, Dakshina Kannad Karnataka. The main campus is situated 5 Km awa

m Puttur town (45°N latitude, 75.4°E longitude and MSL). Out of 69.02 ha of land contemplated for equisition, 68 ha have already been acquired for laying out field experiments at Kemminje. Besides the main campus housing Laboratory-cum-Administrative Block, Experimental Station at Shantigodu with an area of 80 a which is 13 Km away from the main campus also rms part of the Research Centre.

The research programmes are pursued in the eas of Crop Improvement, Crop Management, Crop tection, Post - Harvest Technology and Transfer of chnology. Besides a well equipped Biotechnology aboratory, the research centre has sophisticated struments/facilities for conducting research.

The centre has got well established library in the field of cashew research. It is equipped with 884 books, 759 reprints, Indian and international periodicals (38 and 9) and their back volumes (851) and Annual Reports of ICAR and other Institutes. In the library there are 210 gratis publications / reports. The library is serving as an information centre on all aspects of cashew research and development in the country. The CD databases viz., CABHORT, CABPEST, AGRICOLA and AGRIS are also available in the library. The library is equipped with automation software and barcoding facility.

The centre has a local area network of ten computers. The computers in this network have CD ROM facility. The Centre has also got Internet connection and a separate e-mail account. The Centre has got its website and the URL is http://www.kar.nic.in/cashew/.

The headquarters of AICRP on Cashew is located at NRC Cashew, Puttur. It has eight Coordinating Centres and one Sub-Centre located in Karnataka, Kerala and Maharashtra in the West Coast, Andhra Pradesh, Orissa, Tamil Nadu and West Bengal in the East Coast and in Chhattisgarh which is a non traditional cashew growing area.

Achievements of the centre:

- It has the largest germplasm collection of cashew in the country (NCGB) with 451 accessions. A total of 392 cashew accessions have been assigned with National Collection numbers.
- It has released two selections namely NRCC Sel-1 and NRCC Sel-2, which are high yielding, and medium nut types for cultivation in Karnataka. However, Sel-1 is not being multiplied for distribution to farmers because of its poor performance.
- In micropropagation, regeneration of cashew from the seedling explants (nodal cultures) has been standardised. Micrografting technique for in vitro multiplication of cashew has been standardised and cashew plants raised by micro grafting have been potted.
- It has also demonstrated the advantage of growing intercrops like pineapple profitably in cashew gardens.
- High density planting (625 plants/ha) was shown to be better than normal spacing (8m x 8m) resulting in a yield increase by 2.5 times over control.
- 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 yield.
- Soft-wood grafting method has been standardised and its feasibility for the commercial multiplication has been demonstrated.
- The rearing technique for cashew stem and root borer (CSRB) on host bark has been standardised. Volatiles and extracts in hexane from both healthy bark and frass on testing by EAG elicit response from adult female beetles of CSRB.
- Blending of defatted cashew and soybean flour in equal proportion improves the water absorption and emulsification capacity of cashew defatted flour. Sweetened and flavoured spread could be prepared from cashew kernel baby bits. Optimum coating of baby bits with honey and cane sugar occurs at 100°C at 70%

concentration. 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 eight months at ambient temperature.

- The centre has established very good linkage with farmers and officials of State Departments and Developmental agencies. It conducts training programmes on cashew production technology, vegetative propagation of cashew and utilization of cashew apple. Besides these training programmes, plant protection / soil and water conservation campaigns and field days are being conducted for the benefit of farmers.

Budget

The institute had an annual budget of Rs. 84.0 lakh under plan and Rs.127.00 lakh under non-plan for the year 2001-2002. Besides, the research is supported to the tune of 15.65 lakhs through external funding.

Staff Position as on 31.3.2002

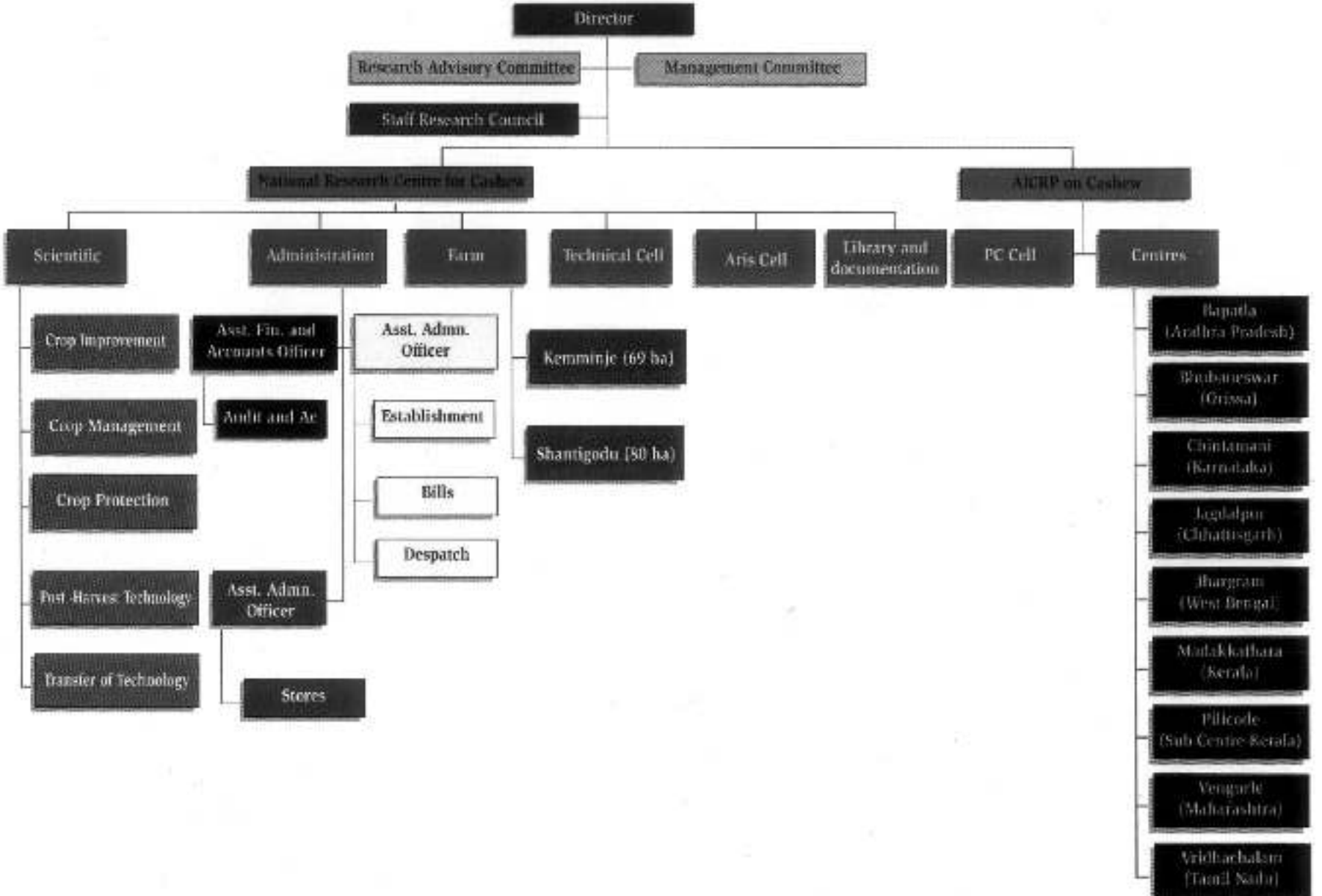
	NON PLAN			PLAN			TOTAL		
Category	Sanct-ioned	Filled	Vacant	Sanct-ioned	Filled	Vacant	No. of Posts	No. filled	Vacant
Director (RMP)	1	1	-	-	-	-	1	1	-
Scientific	16	15*	1	-	-	-	16	15	1
Technical	22	21	1	4	-	4	26	21	5
Administrative	14	14	-	1	-	1	15	14	1
Supporting	43	43	-	-	-	-	43	43	-
Total	96	94	2	5	-	5	101	94	7

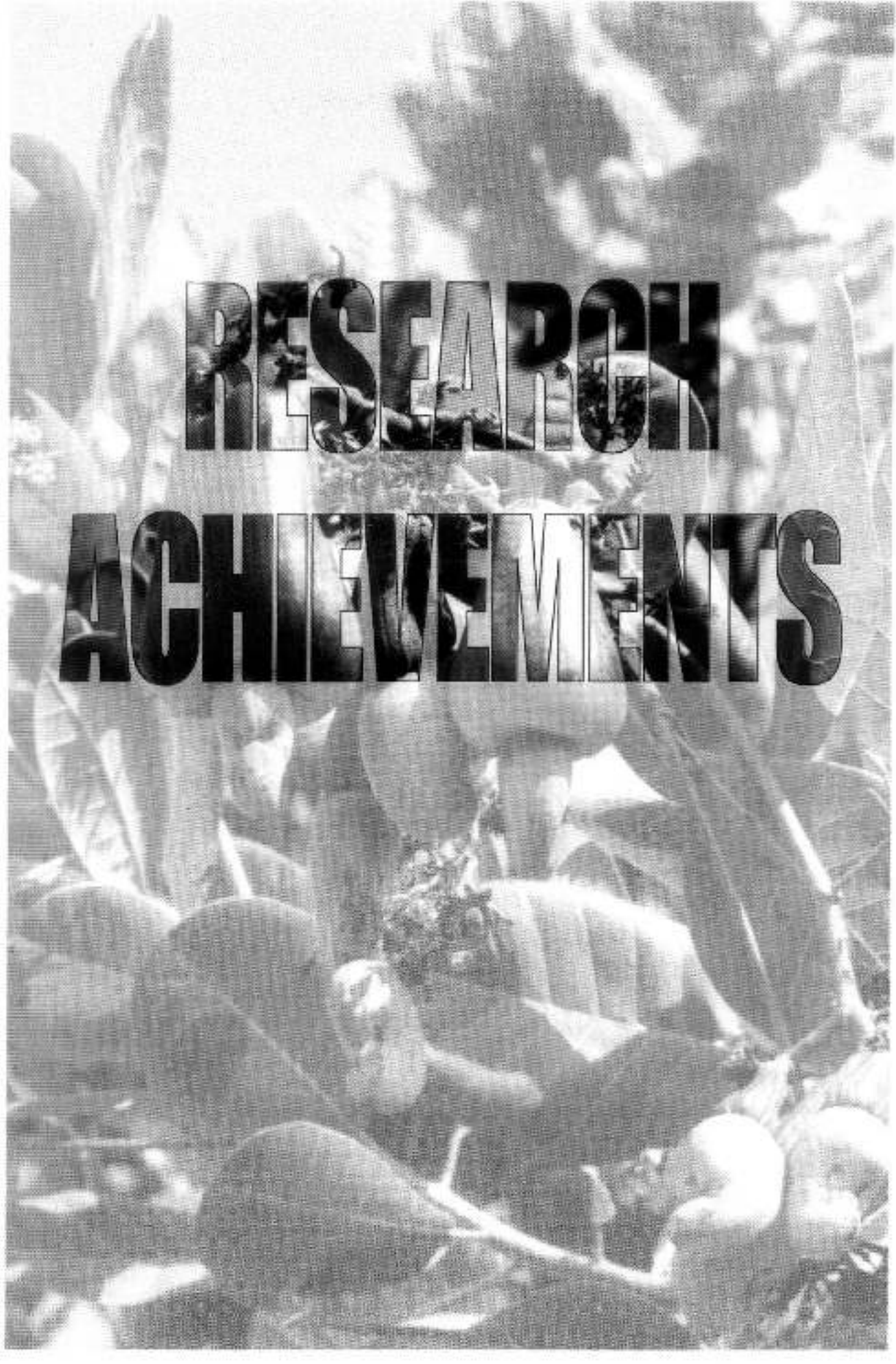
* One Scientist's (AS and PE) post is temporarily adjusted against vacant post of Scientist (Plant Physiology)

Total Manpower

	Sanctioned	Filled	Vacant
Non Plan	96	94	2
Plan	5	-	5
Total	101	94	7

ORGANISATIONAL SET UP OF NRC-CASHEW




RESEARCH
ACHIEVEMENTS

1. CROP IMPROVEMENT

1.1 Genetic resources of cashew

During the year, efforts were continued to collect indigenous and exotic germplasm for conservation in the National Cashew Gene Bank (NCGB). These accessions are being evaluated and catalogued.

1.1.1 Germplasm collection, conservation and utilization

A total of 12 accessions from Karnataka (2), Kerala (3), Goa (3), Tamil Nadu (3) and Andhra Pradesh (1) were collected. Eight more accessions were collected from Orissa (4) and Maharashtra (4) under the Ad-hoc scheme. The scions from these accessions were grafted on the root stock seedlings for production of clones (Table 1.1). The 18 accessions collected from Maharashtra (12), Andhra Pradesh (4), Kerala (1), and Karnataka (1) have been planted at 6m x 6m spacing in NCGB at Shantigodu (6grafts/accession) taking the number of accessions conserved so far in NCGB to 451 (Table 1.2). A total of 42 accessions in NCGB identified based on genetic diversity, and complimentary characters were used as parents for hybridization programme under Ad-hoc scheme during 2001-2002 fruiting season (Table 1.3).

Table 1.1: Cashew germplasm collected during 2001.

	Collection number	Characteristics
	Shadymane-1	
	Shadymane-2	
	Hybrid 5/11 (Mother tree)	
	M 11/2	
	M 16/3	
	M 15/4 (VRI-4)	
	Anakkayam-1	
	Anakkayam-2	
	Anakkayam-3	
	Torla-1	
	Katel paz-1	
	Estamol-1	
	Tapang-1	

	Collection number	Characteristics
	Bhanjha Kusum-1	High yield (40 kg), small sized nuts (4 g) and cluster bearing, high shelling percentage (38 %).
	Ranasingpur-1	High yield (40 kg), small sized nuts (4 g) and cluster bearing, high shelling percentage (38 %).
	Ranasingpur-2	High yield (20 kg), small sized nuts (5 g) with cluster bearing habit, high shelling percentage (40 %)
	Wangni-1	High yield (15 kg), medium sized nut (6.6 g) and big sized apple (120 g), high shelling percentage (31 %)
	Ghosale-1	High yield (10 kg) bold sized nuts (8.7 g) and big sized apple (120 g)
	Amboli Karanjeveera-1	High yield (65 kg), medium sized nuts (7.3 g)
	Amboli Karanjveera-2	High yield (40 kg), small sized nuts (6.6 g)

Table 1.2: Details of germplasm accessions conserved in NCGB

State	Number of accessions		
	Existing		Total
Maharashtra	29		41
Goa	42		42
Karnataka	114		115
Kerala	60		60
Tamil Nadu	39		39
Andhra Pradesh	97		101
Orissa	17		17
West Bengal	14		14
Exotic	21		21
Total	433		450

Table 1.3: Cashew accessions from NCGB identified as parents for the hybridization programme during 2001-2002.

Female parents (30)	8, 10,12, 14, 17, 25, 27, 39, 40,42, 62, 65, 88, 96, 104, 106, 113, 114, 141, 146, 155, 166, 187, 203, 205, 207, 214, 224, 227, 245
Male parents (12)	87, 91, 92, 107, 111, 158, 162, 174, 190, 216, 223, 251

1.1.2 Germplasm evaluation

a) Characterisation of germplasm

After completion of six annual harvests, fourteen accessions in NCGB (planted in 1991) were evaluated and characterised as per IPGRI cashew descriptors during the year 2001-2002 taking the total number of accessions characterised so far to 269. Of the 14 accessions characterised, majority of the accessions had upright and open tree habit (13), extensive typ of branching (10), early season (Nov-Dec) flowerir (12), yellow colour of mature cashew apple (13 conical-obovate shape of cashew apple (14), loo attachment of nut to cashew apple (10), intermedia weight/nut (10), medium weight/apple (10), mediu ratio of apple to nut (11), high shelling percentage (1 intermediate weight/kernel (12), intermediate sh thickness (13), loose attachment of peel to kernel (1

and low yield/plant (14). Natural incidence of TMB was recorded on these accessions in NCGB by adopting a 0-4 scale and the shoots and panicles were graded for damage. All the 14 accessions were found to be highly susceptible with damage score of 3.1 to 4.0.

b) Biochemical evaluation of cashew apple juice

Cashew apple juice from core collections and parents identified for crossing programme were analysed for tannin, sugar, ascorbic acid, and organoleptic acceptability in order to identify accessions suitable for development of cashew apple products. Based on the variability observed in accessions, a quality index has been developed by ascribing equal weightage for tannin, sugar, ascorbic acid and MCH (Table 1.4). Based on the values for various cashew apple constituents, weightage ascribed and cumulative weightage is calculated. A accession with cumulative weightage of 12 and mo is considered better with desirable characters such a low tannin, high sugar and ascorbic acid and bett acceptability. Variability noticed among accessior analysed so far, which included core collections, an parents identified for crossing programme is presente in Table 1.5. Accessions with quality index of 12 an above are better. Among the accessions analysed s far, NRC 190 has the highest quality index of 1 whereas, NRC 155 has got the least quality index of 5 Similarly, cashew apple juice from released varietie of cashew was analysed and quality index is presente in Table 1.6. Out of 32 varieties analysed, nine varietie had quality index of 12 and above.

Table 1.4: Weightage ascribed to various cashew apple juice constituents.

Constituents	Range	Weightage
Tannin (unclarified juice)	< 1 mg/ml	5
	1.01 to 2.0 mg/ml	4
	2.01 to 3.0 mg/ml	3
	3.01 to 4.0 mg/ml	2
	> 4.0 mg/ml	1
Sugar (clarified)	> 200 mg/ml	5
	151 to 200 mg/ml	4
	101 to 150 mg/ml	3
	50 to 100 mg/ml	2
	< 50 mg/ml	1
Ascorbic acid (clarified juice)	> 4.0 mg/ml	5
	3.01 to 4.0 mg/ml	4
	2.01 to 3.0 mg/ml	3
	1.01 to 2.0 mg/ml	2
	< 1.0 mg/ml	1
MCH (Mean cumulative hedonic score)	< 15.0	5
	15.0 to 16.0	4
	16.1 to 17.0	3
	17.1 to 18.0	2
	> 18.0	1

Table 1.5: Quality index for cashew apple juice constituents for accessions of NCGB

Quality Index	Accessions
5	NRC 155
6	NRC 279, 214, 18
7	NRC 159, 13, 120, 205, 130, 140, 111, 160, 166, 164
8	NRC 241, 107, 100, 146, 88
9	NRC 72, 217, 4, 66, 175, 192, 162, 225, 187
10	NRC 233, 245, 176, 9, 235, 244, 92, 8
11	NRC 80, 133, 247, 202, 65, 25, 62, 193, 158, 191, 109
12	NRC 228, 3, 35, 112, 43, 157, 141, 227, 126, 84, 39, 223, 216
13	NRC 127, 236, 56, 87, 10, 17, 207, 218
14	NRC 59, 79, 81, 114, 251, 113, 27
15	NRC 203
16	NRC 42, 224
17	NRC 190

Table 1.6: Quality index for cashew apple juice constituents of released varieties.

Quality index	Varieties
6	BPP-5*, VTE, Priyanka, BPP-3*
7	Kanaka 0
8	NRCC Sel-2, V-4, BLA 39-4, BPP-6, Dhana
9	BPP-2*, V-6, Ullal-4, V-7
10	BPP-4, VRI-2*, Dilal-3, Ullal-2*
11	VRI-3, Bhubaneswar-1, Goa-1, NDR-2-1, V-1
12	BPP-8, VRI-1*, PLN-30, K-22-1
13	NRCC Sel-1*, BLA 39-1*, V-3*, BPP-1*
14	Nil
15	Jhargram-1

* These varieties are not currently multiplied for distribution to farmers

c) DNA finger printing of cashew accessions

DNA finger printing of cashew germplasm is being carried out in collaboration with Division of Horticulture, UAS, Bangalore and NRC for DNA Finger Printing, New Delhi. The RAPD analysis of 90 accessions carried out at UAS, Bangalore, (Squared Euclidean distance, Ward's Clustering) has revealed that the diversity in Indian Cashew germplasm is moderate and not narrow as reported.

Isozymes of peroxidase, esterase, aspartate aminotransferase (AAT), acid phosphatase, leucine aminopeptidase and superoxide dismutase were studied in leaves of young flushes (3rd and 4th) of which esterase and aspartate amino transferase alone gave polymorphic bands.

d) Assignment of National collection numbers to cashew germplasm

The passport information on all the accessions which have been conserved in different cashew growing states was obtained in the proforma supplied by NBPGR, New Delhi. After separating the duplicates available at different centres, the passport information for the remaining accessions (1149) was sent to NBPGR, New Delhi for assigning IC Nos. IC nos. have been assigned by NBPGR, New Delhi, for a total of 1149 cashew accessions which are being conserved in the National Cashew Gene Bank at Puttur (433) and the Regional Cashew Gene Banks at AICRP on Cashew centres, namely, Chintamani (53), Vengurle (142), Pilicode (64), Madakkathara (73), Vridhachalam (250 Bapatla (80), Bhubaneswar (5) and Jhargram (49).

e) Preparation of district-wise gemplas collection maps

Based on the original source of collectio district-wise germplasm collection maps for 11 cashew accessions which are conserved in NCGB NRCC, Puttur (451) and in RCGBs at AICRP on Cashe Centres, namely, Chintamani (53), Vengurle (142 Pilicode (64), Madakkathara (73), Vridhachalam (250 Bapatla (80), Bhubaneswar (5) and Jhargram (49) ha been prepared. These accessions have been collecte from nine cashew growing states namely, Karnatal (176), Andhra Pradesh (221), Kerala (209), Maharasht (136), Orissa (21), Tamil Nadu (277), West Bengal (36 Goa (46) and Assam (3) and from abroad (42 A technical bulletin entitled "Status of cashe germplasm collection in India" has been published.

f) Stool layering of cashew accessions

In order to explore the possibility of producir stool layers for utilizing them as rootstocks, four ye old plants of Cuddalore-1 (S 28) and Kodippady-2 29) were headed back to a height of 15 cm from grour level during August 2001. The stumps sprouted with six weeks and these sprouts were allowed to grow f six more weeks. The basal portion of the shoots w covered with sand for etiolation during October 200 After 40 days of etiolation, the sand was careful removed, and the basal portion was girdled (2.5 c

ring of bark was removed) during November 2001. The upper portion of the girdled area was smeared with rooting hormone (IBA 500 ppm). Then the shoots were covered with a mound of sand. Regular watering was done to keep the sand moist. After 2½ months, the rooted stool layers were separated during February 2002 and were planted in the polybags. A total of seven plants were headed back. Rooted stool layers from four plants were separated and planted in polybags in the nursery. Of the 41 stool layers prepared, 16 have produced good number of roots (39%) and only five have established (31.2%) in polybags.

Stool layers

g) Intergeneric grafting in cashew

In order to explore the possibility of utilizing related genera of Anacardiacae as root stocks for cashew, the seedlings of mango (*Mangifera indica*) and Chere (*Holigarna grahami* and *H. ferruginea*) were grafted with scions of cashew (*Anacardium occidentale* L.) during August 2001 by adopting softwood grafting technique. The seedlings of cashew were also grafted with scions of mango and cashew. The inter generic grafting was not successful.

1.2 Varietal improvement of cashew

Efforts have been made for the genetic improvement of cashew for yield, nut weight (7 g), kernel weight (> 2 g), and shelling percentage (>28%). A total of 2000 hybrids from 210 cross combinations and 290 selfs are under evaluation in different age groups.

1.2.1 Relationship of flowering and fruiting characters with yield

The correlation analysis of flowering and fruiting characters vis a vis yield/tree showed that number of flowering laterals/m^2 of canopy, fruiting intensity (number of nuts/m^2 of canopy), nut yield/m^2 of canopy have high positive correlation with estimated yield/tree. Fruiting intensity and yield/m^2 of canopy had high positive correlation with estimated yield/tree in the current year (+0.946 and + 0.942 respectively) (Table 1.7). Regression analysis showed coefficient of +0.449 of estimated yield/tree on fruiting intensity. The results of correlation and regression analysis over the last four years showed that fruiting intensity and nut yield/m^2 of canopy are the most important yield component characters and hence these characters can be used for evaluating breeding material for improvement of nut yield/tree.

1.2.2 Evaluation of hybrids/selfs for improvement of nut size in released varieties.

Two promising hybrids, namely, H-46 (BPP-6 x A 18/4) and H 32/4 (BPP-5 x VRI-1) are under field evaluation at Karnataka Cashew Development Corporation (KCDC), Puttur Division. H 32/4 is under

Table 1.7: Correlation and regression coefficients of flowering and fruiting characters (X) with estimated yield (Y) in 18 varieties of cashew

Characters (X)	Correlation coefficient(r) of characters with estimated yield/tree	Regression coefficient (b) of estimated yield/tree (Y) on independent characters (X)
Number of flowering laterals	0.470	0.252
Flowering lateral intensity	0.057	0.006
Fruiting intensity	0.946	0.449
Yield/m^2 of canopy	0.942	0.082

evaluation in some selected farmers' fields also. High annual yield of 3.86 kg/tree in sixth harvest and highest cumulative yield of 11.88 kg/tree for six harvests were recorded in S-15/14 (1/3 Ceylon self) in a replicated trial with six hybrids, one self and four controls. In the same trial VRI-2 (control) gave annual yield of 2.46 kg/tree and cumulative yield of 7.07 kg/tree in the same harvest. In another replicated trial, hybrid H 24/4 (BLA 139-1 x A 18/4) performed well both for annual yield (2.67 kg/tree in third harvest) and for cumulative yield (5.34 kg/tree for three harvests) as against annual yield of 0.64 kg/tree and cumulative yield of 1.77 kg/tree in case of VRI-2 (control).

Hybrid H-1250

Hybrid H - 1205

A total of 2000 hybrids from 210 cross combinations are under evaluation in different age groups. Further, more than 290 selfed seedlings (F2 generation) of hybrid Tree No. 1393 of VRI-2 x VTH 711/4 are also in the initial stage of evaluation. Three hybrids, namely, H 1250 (VRI-2 x VTH 40/1), H 1205 (VRI-2 x VTH 40/1) and H 1354 (V-5 x VTH 711/4) having medium nut size performed well for cumulative yield for seven harvests (14.15 kg/tree, 13.35 kg/tree and 12.45 kg/tree, respectively).

1.2.3 Status of adherence of testa to the kernels

Thirty six released varieties of cashew were evaluated for status of adherence of testa to the kernel by recording the number of strokes of scraping knife required for removal of testa fully from the kernel. The varieties differed for this character and they were classified into three categories, namely, loose adherence (< 5.0 strokes), medium adherence (5.0 - 7.5 strokes) and tight adherence (> 7.5 strokes). Loose adherence types are preferred by cashew processing industries as there is savings in labour involved, lesser damage to the kernels and higher recovery of wholes. Out of the 36 varieties, two varieties had loose adherence, 28 varieties had medium adherence while the remaining six had tight adherence of testa.

1.2.4 Composition of cashew pomace of released varieties

Cashew apple pomace from 27 varieties was analysed for fibre, protein, carbohydrate (starch), and sugar content. Pomace protein content among the varieties analysed varied from 17.77% (V-2) to 31.11% (BLA 139 1). Carbohydrate content showed variation from 28.79% (BPP-5) to 47.41% (V-4). Sugar content among the varieties analysed varied between 0.165% (VRI-1) and 1.393% (BPP-5). Fibre content varied from 11.64% (V-4) to 18.30% (V-1) (Table 1.8).

1.3 Micropropagation

1.3.1 Regeneration from nodal cultures (grafts).

A total of 1092 nodal explants from young cashew grafts of four varieties namely NRCC Sel-1, Sel-2, Ullal-3 and Kodippady were cultured and 19.8 to 64.3% bud break and 0 to 44% shoot development were observed. Bud break was maximum during December and March. Shoots excised from micro grafts responded better in terms of bud break and shoot development. Significant varietal difference was noticed with regard to percent bud break. Shoots from NRCC Sel-1 had higher percentage of bud break (67.6%) than others. Position of bud in the nodes also influenced percent bud break. The lower (older) nodes

Table 1.8: Composition of cashew apple pomace (mg/100 mg) of released varieties of cashew

Variety	Protein	Carbohydrate (starch)	Sugars	Tannin	Fibre
Selection-1	30.65	46.54	0.479	0.085	15.65
Selection-2	19.96	43.26	0.430	0.172	13.17
NDR-2-1	28.94	46.47	0.395	0.073	14.26
BLA-139-1	31.81	47.40	0.664	0.128	14.03
Kanaka	23.65	37.66	0.232	0.084	4.82
K-22-1	23.01	45.92	0.464	0.115	14.10
BLA-39-4	18.73	42.00	1.256	0.224	14.41
Ullal-2	21.34	35.89	0.292	0.081	13.27
Ullal-3	26.36	42.55	0.545	0.108	11.73
Ullal-4	24.99	41.54	0.389	0.081	11.38
VRI-1	20.50	45.69	0.165	0.101	14.57
VRI-2	25.65	38.55	0.445	0.122	15.31
VRI-3	24.08	45.31	1.064	0.128	9.69
BPP-1	20.12	35.56	0.262	0.161	17.36
BPP-3	21.36	44.63	0.350	0.149	16.59
BPP-4	22.99	36.47	1.392	0.145	13.23
BPP-5	24.69	26.79	1.393	0.276	14.36
BPP-6	18.39	36.28	0.469	0.161	16.32
BPP-8	25.16	41.24	0.739	0.152	16.37
V-1	21.26	35.38	0.315	0.132	14.70
V-2	17.27	40.91	0.986	0.418	14.42
V-3	18.98	40.32	0.314	0.125	13.89
V-4	21.29	47.41	0.732	0.094	11.61
V-6	23.35	37.89	0.490	0.110	12.87
Goa-1	20.49	37.73	0.372	0.137	17.96
Bhubaneswar-1	22.68	42.82	1.170	0.206	13.58
Ihargram-1	21.30	44.60	1.389	0.186	15.11

Values are mean of three individual estimations

showed quick response with lower contamination. Incorporation of Gibberelic acid (GA_3) or 6-benzyl amino purine (BA) at 5 µM concentration in MS medium resulted in higher percentage of bud break and shoot development. Three sub culture media tried viz., MS with 4% sucrose, full MS with 4% sucrose and SH medium had no significant effect in enhancing the growth of shoot culture. Thidiazuron (TDZ) at 0.1 mg/l, putrescine (100 µM) and spermidine (20 µM) tried alone and TDZ (0.1 mg/l) in combination with above polyamines showed axillary shoot-bud induction only in media containing TDZ and its combination with polyamines. Polyamines suppressed axillary shoot-bud induction.

Significant difference in shoot length and leaf number was not observed when shoot-bud elongation was attemped at different levels of sucrose (3 to 6%). Proliferated shoots on medium containing putrescine (10 µM), spermine (20 µM), putrescine (200 µM) + 2iP (2 mg/l) and 2iP (2 mg/l) + IBA (0.1 mg/l) also showed no elongation of shoot-buds. In the trial for elongation with two media namely (i) WPM medium containing salts, Nitsch vitamins, MES (500 mg/l) and BA (1µM) and (ii) MS liquid medium with 4% sucrose, only latter showed limited elongation (33.3%). *In vitro* rooting attempted by slow dip method viz., 24 h dip (dark) in 100 ppm NAA / IBA and culturing of shoots in WPM medium with or without 1 mg/l IBA showed no indication of rooting. Similarly, quick dip of microshoots in 5 and 10 mM IBA for a min followed by culturing on WPM medium with or without IBA (1 mg/l) and hormone free MS medium showed no rooting. Even combination of paclobutrazol (0.5 mg/l) with NAA (5 mg/l) and NAA + IBA (2.5 mg/l) was helpful, indicating recalcitrance nature of cashew tissue for regeneration.

1.3.2 Micrografting

Root-stock seedlings for micrografts were raised by germinating mature seeds *in vitro*. Among the various sterilants tried for sterilization of seeds, 0.1% mercuric chloride for 15 min gave highest germination(82.9%) with minimum contamination (17.1%). Among five media tried for germination of seeds, bottles containing absorbent cotton presoaked with distilled water was the best followed by filter paper on water and soil-rite medium. Twenty micorgrafts of two varieties (Ullal-2 and NRCC Sel-1) have been field planted at 5m x 5m spacing along with normal grafts for evaluation.

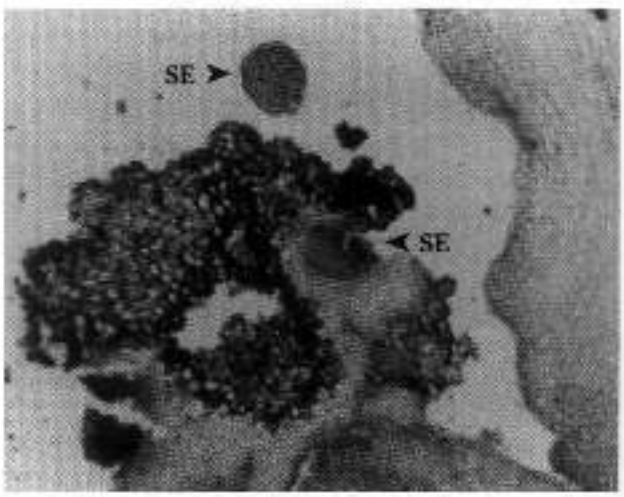
1.3.3 Leaf culture for somatic embryogenesis

Callus induction and somatic embryogenesis were attempted in leaf segments (1 sq cm) cultured from *in vitro* shoot culture and *in vitro* seedlings on MS medium containing thiamine (10 mg/l), cysteine HCl (33 mg/l) and 2,4-D (2.5, 4.5 µM) and kinetin (Kin) (10, 20, 30, 40 µM) in varying combinations. Leaf segments from *in vitro* shoot cultures responded only with leaf expansion and leaf curling and showed no callus formation, whereas, the leaf segments from *in vitro* raised seedlings showed callus induction with 45% of the cultures exhibiting profuse root formation. Embryogenesis was not observed when the calli was subcultured on hormone free MS medium or MS media with low levels of 2,4-D (0.5, 2.5 µM) and alar (2 mg/l).

Somatic embryoid differentiation in nucellus callus

1.3.4 Nucellus culture for somatic embryogenesis

Callus could be induced in bisected ovules of 2-5 week old immature nuts of Ullal-3, VRI-2, H-4-7 and NRCC Sel-2. The callus grew fast initially and then slowed down after two weeks and became brown. When slow growing calli (105 no.) were transferred to embryogenesis induction media, three cultures (3%) showed embryogenesis. Embryogenesis was observed mainly on three media namely (1) RBM basal medium (2) RBM + Kin (12µM) + alar (2 mg/l) (3) MS basal medium + Sucrose (4%) + thiamine (10 mg/l) + Kin (30µM) + 2,4-D (5µM). The results indicated that when callus induction media contained only low concentration of 2,4-D, a simple hormone free medium (RMB) could give embrogenesis whereas, when callus induction on media containing both kinetin and 2,4-D, a very high concentration of kinetin or the presence of a growth retardant (alar) was required in the differentiating media for induction of embryogenesis. Embryogenesis was observed only in callus of Ullal-3 and H-4-7. Histological studies of the embryogenic calli showed the different stages of embryoid development and differentiation of embryoids from pro-embryogenic cells to globular heart torpedo and early cotyledonary stages were observed. The embryogenic calli on subculturing to semi-solid RBM basal medium gave rise to secondary somatic embryogenesis.



Histological section of nucellus callus differentiation of somatic embryos (SE)

1.3.5 Suspension culture and germination of somatic embryos

Suspension cultures were initiated from embryogenic calli by subculturing 0.2 g of the same on liquid RBM basal medium with constant shaking (100-125 rpm) at 25 ± 2°C. In semi-solid media, the number of embryoids obtained was 25-30 whereas, in the suspension cultures the number of embryoids obtained were at least five fold and embryoids were of uniform size. The embryoids were bipolar structures with prominent root pole and of size ranging from 0.3 - 0.5 cm. When 17 embryoids obtained from semi-solid media were put for maturation on media with ½ MS major salts, full minor, casein hydrolysate (500 mg/l), L-glutamine (400 mg/l) and ABA (2.5, 5.0 mg/l) or CW (20%), four embryoids grew into perfect biopolar structures which were bilaterally symmetrical or assymetrical. On germination media containing B5 (Gamgorg *et al.*, 1968) full major salts + full MS minor salts, organics and GA3 (0, 3 µM) only two showed perfect root formation with no shoot development. When embroids from suspension cultures were cultured on five media with varying combination of GA3 (1.5 µM) and ABA (14, 18.9 µM) in three replications @ 3-5 embryoids / treatment there was slight increase in size of somatic embryos but no germination was seen. On the other hand callus formation was observed in some of these cultures.

1.3.6 Evaluation of micropropagated plants

The micropropagated plants of VRI-1, H-4-7, BLA39-4 and VTH-762/4 (dwarf) planted in 1997 showed flowering during this season. Fruit set was observed in all the varieties except in dwarf type. BLA39-4 had maximum height (3.53 m) and dwarf variety had the least height (1. 36 m). Similarly, stem girth was least (3.66 cm) in dwarf and maximum in VRI-1 (10.3 cm). In the replicated trial planted in 1999 with micropropagated plants of H-4-7 and VRI-2 along with their grafts, micropropagated plants of H-4-7 had significantly more girth (5.04 cm) and height (1.71 m) than grafts (4.6 cm and 1.53 m respectively), while micropropagated plants of VRI-2 had girth equal to that of grafts and more height than grafts.

2. CROP MANAGEMENT

2.1 Planting systems and spacing

The study was initiated to understand growth of cashew under different systems of planting and spacing, both under pruned and unpruned conditions. The experiment was laid out following split plot design with three replications. The main plot treatments included square systems namely 5.0 m x 5.0 m (400 plants/ha), 6.5 m x 6.5 m (236 plants/ha), 8.0 m x 8.0 m (156 plants/ha) and hedge systems namely 5 m x 4 m (500 plants/ha), 6.5 m x 4.0 m (384 plants/ha) and 8.0 m x 4.0 m (312 plants/ha) with pruning and no pruning as sub plot treatments.

The tree height increased significantly (6.54 m) in high tree density plot (500 trees/ha) over low tree density plot (4.12 m - 156 trees/ha). The tree density had no effect on girth of stem. Effective canopy height was significantly more in low tree density plots (156, 236, 384 and 312 trees/ha) than high tree density plots (Table 2.1).

In hedge row system of planting, canopy spread in EW direction was significantly more than square system of planting. Ground coverage by crop canopy was significantly more in high tree density plots in 500 trees/ha plot and in 400 trees/ha plot (Table 2.1). Light interception was significantly higher in high tree density plot (82 and 95% in plots with 400 and 500 trees/ha) than low tree density plots (49 to 52% in 156 trees/ha plot, 68 to 80% in 236 trees/ha plot and 72 to 82% in 312 trees/ha plot).

Annual total cashew leaf deposit collected at the base of the plant was 2.85 and 2.95 t/ha in high tree density plots (400 and 500 trees/ha). Next highest leaf deposit was in plot with 384 trees/ha (2.65 t/ha). Lowest leaf deposit was noticed in plot with 156 trees/ha (0.6 t/ha). The nutrients available for recycling in leaf deposits were maximum in high tree density plots (400 and 500 trees/ha) and minimum in lowest tree density plot (156 trees/ha).

It was observed that organic matter, available N in soil up to 1 m depth was higher in high tree density plots (400 and 500 trees/ha) than in low tree density plot (156 trees/ha). However, no definite trend was observed with respect to P and K contents in soil among different tree density plots. Yield of 361, 304 and 245 kg/ha was realized from plots with 384, 500 and 312 trees/ha respectively (Table 2.2).

Highest cumulative yield both under pruned and unpruned conditions was realized from high tree density plots (500 and 384 trees/ha). Lowest cumulative yield was realized from plot with 156 trees/ha both under pruned and unpruned conditions (1282 and 1482 kg/ha) (Table 2.2). Maximum profit of Rs. 73,735/ha from high tree density plot of 384 trees/ha was realized over 10 years which was 2.4 times that of profit realized from normal tree density plot (Rs. 31,278 in 156 trees/ha plot). Next higher profit was realized from high tree density plots of 500 and 400 trees/ha (Rs. 70,050 and 58,790/ha respectively) (Table 2.3).

2.2 Canopy management studies in cashew

Canopy management studies were initiated during the year 1992-93 with an objective of studying the effect of pruning on canopy containment, flushing, flowering and yield of cashew. Four cashew varieties viz., VRI-1, Ullal-1, VTH 30/4 and NRCC Sel-1 were used for the study. Pruning treatments such as yearly pruning (leader shoot pruning + general pruning), alternate year pruning (leader shoot + general pruning) and shape pruning (general pruning) are regularly imposed. An unpruned plot was maintained for comparison. The pruning treatments were imposed since 1995 and the 4th cycle of pruning has been imposed during the year.

2.2.1 Effect of pruning on yield

Nut yield during the year 2000-01 remained unaffected due to different pruning treatments (Table 2.4). There were less number of nuts in the panicles of yearly pruned trees (5.42) compared to shape pruned (6.00) or unpruned trees (6.58). The nut and apple weight was lower in yearly pruned trees.

2.2.2 Effect of pruning on plant growth

Pruning had no effect on canopy spread. The number of flowering laterals due to yearly pruning (15.95) and alternate year pruning (14.90) was less than unpurned (16.58) or shape pruned trees (16.13) while the number of non flowering laterals was more in yearly pruned trees (6.54), alternate year pruned

Table 2.1: Effect of tree density on stem girth, tree height, canopy height, canopy spread (NS and EW) and ground coverage.

Spacing (m)	Tree density (nos/ha)		Tree height (m)			Canopy height (m)			Canopy spread (E-W) (m)				Ground coverage (%)		
			A	B	Mean	A	B	Mean	A	B	Mean		A	B	Mean
5 x 5	400		5.25	5.25	5.25	1.06	1.08	1.07	5.75	5.27	5.51		91.56	86.58	89.22
6 x 6.5	236		5.25	4.60	4.94	1.35	1.36	1.35	6.25	7.25	6.80		84.23	90.50	87.36
8 x 8	156		4.12	3.71	3.91	1.90	1.94	1.92	6.54	6.25	6.39		54.00	50.15	52.07
5 x 4	500		6.54	6.45	6.49	0.99	0.97	0.98	5.54	6.00	5.77		100.0	100.00	100.00
6.5 x 4	384		5.67	5.62	5.64	1.23	1.24	1.23	6.08	5.08	5.58		84.32	71.44	77.80
8 x 8	312		6.13	5.37	5.75	1.36	1.28	1.32	6.71	7.12	6.91		89.00	96.00	93.50

A - Pruned, B - Unpruned

Table 2.2: Effect of tree density under both pruned and unpruned conditions on annual and cumulative yield

Tree density (nos./ha)	Annual yield				Cumulative yield	
	kg/tree		kg/ha		kg/ha	
	Pruned	Unpruned	Pruned	Unpruned	Pruned	Unpruned
400	0.34	0.29	136	114	2992	2787
236	0.99	1.46	233	341	2235	2279
156	1.32	1.72	205	269	1282	1482
500	0.61	0.64	304	319	3424	3433
384	0.94	0.88	361	336	3060	3008
312	0.29	0.78	245	190	2600	2556
CD for main plot	NS					

Table 2.3: Economics of high density planting compared with normal density planting from 1st to 10th year (1991-2000).

Cost (Rs/ha)	Treatment	Spacing and number of trees/ha 5m x 5m (400)	6.5m x 4m (384)	5m x 4m (500)	6.5m x 6.5m (236)	8m x 8m (156)
Labour	Pruned	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Unpruned	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Manure	Pruned	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Unpruned	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cultivation	Pruned	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Unpruned	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Yield	Pruned	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Unpruned	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Net Profit	Pruned	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Unpruned	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table 2.4: Effect of leader shoot pruning on cashew yield.

Treatment	Cumulative yield of first six harvests (kg)	Yield during 2000-2001 (kg)	No. of nuts/ panicle	Weight of nut (g)	Weight of apple (g)
A. Varieties					
VRI-1	16.59	3.04	4.25	6.13	81.67
ULLAL-1	18.70	4.28	6.43	6.98	56.53
VTH 30/4	18.72	3.95	4.92	8.93	92.72
NRCC Sel-1	17.76	3.49	5.92	8.64	86.50
CD for A (P=0.05)	NS	NS	0.76	0.68	2.29
B. Pruning					
No pruning	18.22	3.62	6.58	7.72	74.67
Yearly pruning	17.36	3.68	5.42	7.55	72.58
Alternate year pruning	17.25	3.37	5.42	7.68	75.97
Shape pruning	18.89	3.98	6.00	7.33	74.42
CD for B (P=0.05)	NS	NS	0.76	0.68	2.29
CD for A x B (P=0.05)	NS	NS	NS	0.13	NS

trees (6.64) compared to unpruned (5.79) and shape pruned (5.43) trees respectively (Table 2.5). Length of lateral shoot either flowered or non-flowered did not vary with various pruning treatments. In several trees the twigs dried due to pruning. However, pruning of the thicker branches (3 to 4 cm diameter) resulted in production of multiple shoots which ended with flowers.

2.2.3 Effect of pruning on light interception

On an average only about 10% of light was allowed to reach the ground by plants of four different varieties which were pruned. About 90% 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 16.03% by mid portion of canopy while the bottom (lower) portion of canopy intercepted 2.68 to 14.74% of the light. Top portion of the canopy of pruned trees intercepted more light (86 - 87%) compared to unpruned trees (80.7%) (Fig.2.1 and 2.2). 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 (Fig.2.3). Pruning drastically reduced the leaf area in VTH 30/4 variety.

Vigorous lateral shoot emerging from a pruned branch

Table 2.5: Effect of pruning on plant growth.

Treatment	Canopy spread (m^2)	Number of laterals / m^2		Length of laterals (cm)	
		Flowering	Non-flowering	Flowering	Non-flowering
A. Varieties					
VRI-1	6.51	11.31	8.71	39.92	27.67
Ullal-1	6.45	19.17	4.52	35.33	20.42
VTH 30/4	6.98	13.92	4.58	42.08	28.50
NRCC Sel-1	7.09	19.17	6.60	47.25	35.33
CD for A (P = 0.05)	NS	0.86	0.57	2.73	2.10
B. Pruning					
No pruning	6.30	16.58	5.79	42.25	29.58
Yearly pruning	6.76	15.95	6.54	41.33	27.50
Alternate year pruning	6.53	14.90	6.64	40.75	27.00
Shape pruning	6.75	16.13	5.43	40.25	27.83
CD for B (P = 0.05)	NS	0.86	0.57	NS	NS
CD for A x B (P = 0.05)	NS	NS	1.15	NS	NS

2.2.4 Estimated yield for 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^2, 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 2.6). In NRCC Sel-1 and VRI-1 varieties, pruning had detrimental effect on bearing during this season as per the yield estimation.

2.2.5 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

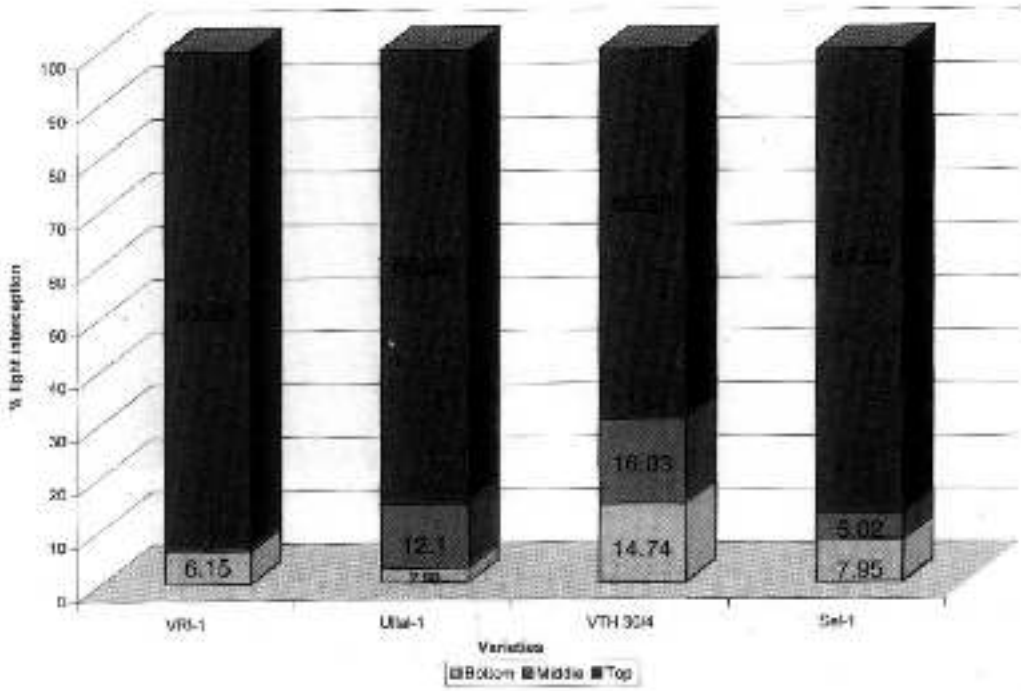


Fig.2.1 Light interception in different cashew varieties

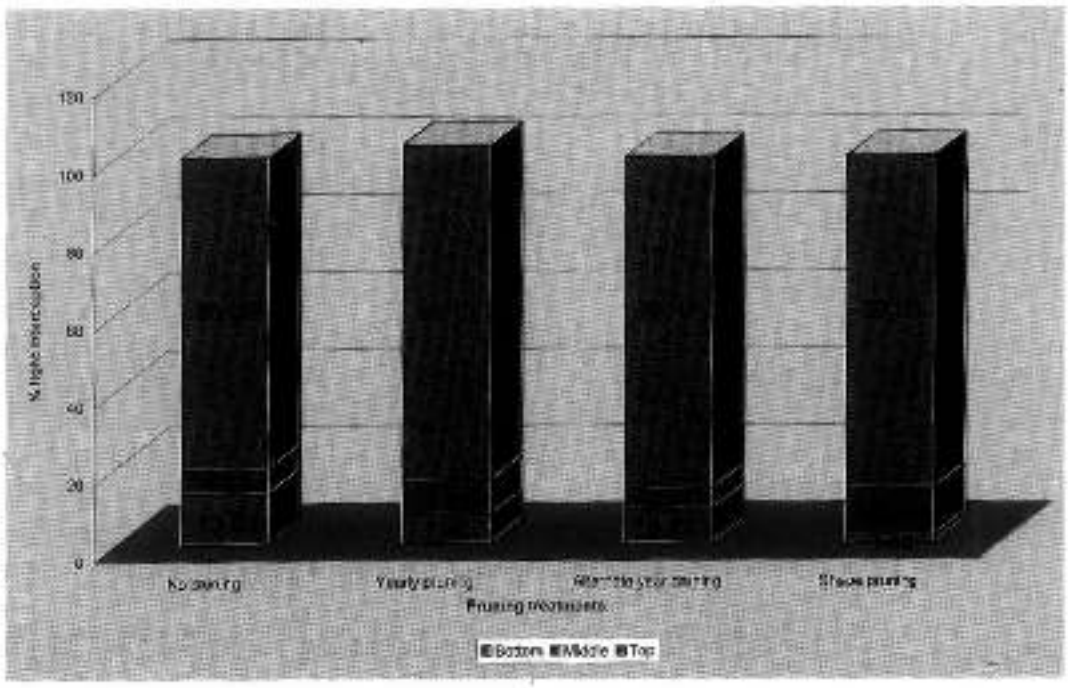


Fig.2.2 Effect of pruning on light interception

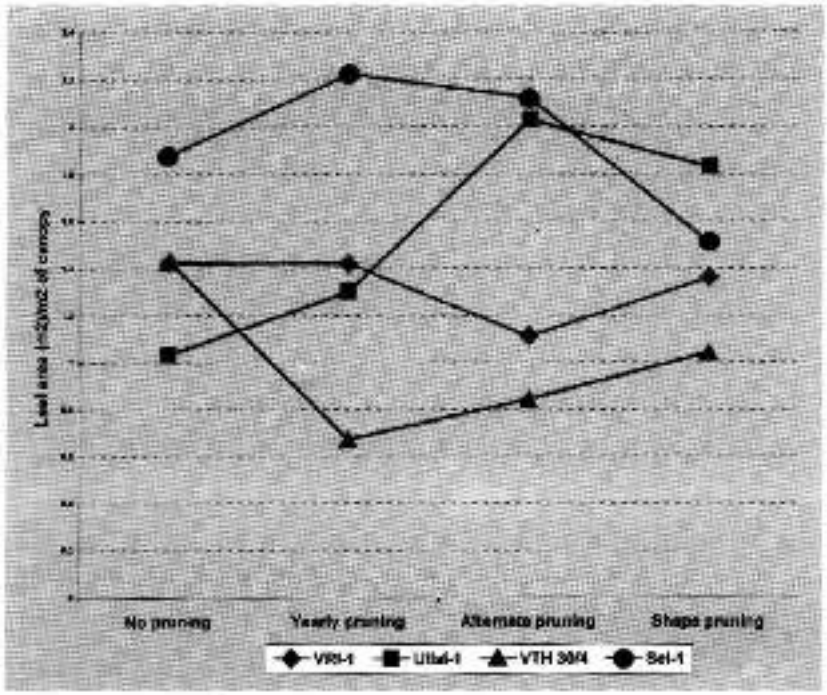


Fig.2.3 Influence of pruning on leaf area

Table 2.6: Estimated yield for the year 2001-02.

Variety	Treatment	Extent of flowering (%)	No. of panicles/m²	Canopy area (m²)	No. of nuts per panicle	Estimated yield / tree (kg)
VRI-1	P_1	95	19.0	21	3	7.35
	P_2	89	16.0	14	3	5.16
	P_3	94	18.0	18	4	7.50
	P_4	92	16.0	13	3	3.80
Ullal-1	P_1	86	15.0	16	8	10.66
	P_2	91	16.0	12	8	10.08
	P_3	82	13.0	15	8	10.68
	P_4	83	13.0	16	8	10.23
VTH 30/4	P_1	90	14.0	16	4	5.80
	P_2	88	13.0	26	4	9.80
	P_3	77	11.0	12	4	3.62
	P_4	76	11.0	17	4	6.00
NRCC Sel-1	P_1	74	9.8	25	4	6.81
	P_2	60	9.6	13	4	4.02
	P_3	45	6.5	15	3	2.63
	P_4	56	8.2	22	4	8.32

P_1 - Unpruned
P_2 - Yearly pruned
P_3 - Alternate year pruned
P_4 - Shape pruned

revealed that the middle layer branches yielded 49.52 % and top portion of canopy yielded 32.9% while bottom layer branches yielded 17.58% (Table 2.7). Even if the plants were pruned yearly or once in two years bearing pattern was similar in top, middle and bott level branches.

Table 2.7: Fruiting pattern at low, middle and top portion of canopy

Treatment	Estimated yield (kg)			
	Low	Middle	Top	Total
A. Varieties				
VRI-1	0.90 (15.52)	3.10 (53.45)	1.80 (31.05)	5.80
Uibl 1	1.86 (18.27)	4.34 (42.94)	3.98 (39.09)	10.18
VTR 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 (51.08)	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. Pruning				
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 (14.85)	3.35 (50.69)	2.28 (34.45)	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	-

Figures in parantheses represent the % light interception at bottom and middle portion of canopy

2.3 Integrated nutrient management for sustainable production of cashew (NATP)

In order to develop suitable combinations of organic and inorganic manures for increasing yield and to explore the possibilities of composting recyclable biomass, an experiment was laid out in 1999 with the following revised treatments.

i) No fertilizer application.

ii) 100% N recommended fertilizer dose.

iii) Bio-fertiliser - Azospirillum with cashew recyclable biomass compost.

iv) Bio-fertiliser - Azatobacter with cashew recyclable biomass compost.

v) 25% N of recommended fertilizer dose and remaining through recyclable biomass compost.

vi) 50% N of recommended fertilizer dose and remaining through recyclable biomass compost.

vii) 75% N of recommended fertilizer dose and remaining through recyclable biomass compost.

viii) 25% N of recommended fertilizer do and remaining through application poultry manure.

ix) 50% N of recommended fertilizer dose a remaining through application of poul manure.

x) 75% N of recommended fertilizer do and remaining through application poultry manure.

In organic farming trial plot, treatme differences in yield was not observed. Organic mat (om) (4.25 - 4.73%) and available N contents (506 - 560 kg) were significandy more in plots receivi 75-100% N in the form of organic manure only wh compared to 50 (2.8% om, 165 Kg N), 25 (2.0% o 135 kg N) and 0% N (1.58% om) in the form of orga manure. Available N was low in all the other treatme plots. K contents were medium in treatment whe 75% and 100% N were applied in the form of orga manure. Leaf N (2.30%) and K (0.59%) contents we more in the above treatments. P concentration in le did not vary significantly due to different manur treatments.

2.4 Efficacy of soil and water conservation coupled with organic and inorganic manuring in cashew garden grown in slopy areas.

Different methods of soil and water conservation techniques to increase production are being evaluated under this programme.

Main plot treatments (4)

(i) Individual tree terracing with catch pit.

(ii) Individual tree terracing with crescent bunding.

(iii) Staggerred trenches between two rows of cashew.

(iv) Control plot without any soil conservation technique.

Sub plot treatments

(i) Application of recommended doses of fertilizers only (750 g N : 150 g each of P_2O_5 and K_2O/tree/year).

(ii) Application of recommended doses of fertilisers + organic manure (10 kg poultry manure).

(iii) Application of organic manure only (20 kg poultry manure).

Design of layout	:	Split plot
Size of main plot	:	20 plants
Size of sub plot	:	4 plants
Replication	:	4

Soil conservation measures like crescent bunding with terrace and staggered trenches resulted in significantly higher production of nuts (Treated - 903 g/tree, control - 706 g/tree). The yield under different treatments like individual terracing and catch pit and staggered trenches did not vary significantly compared to control. Application of poultry manure alone (20 kg) resulted in higher yield (899 g/tree) than recommended doses of fertilizer application alone (577 g/tree). Interaction effects of both soil conservation measures and manures were not observed. Slope of the land ranged from 2.6 to 22%. The annual runoff was 1083 mm of water and annual soil loss was 3.37 t/ha/year. Peak runoff was maximum (5.4 l/s) for individual terracing with catch pit on 22% slope (R3) and minimum (2.5 l/s) for individual terracing with catch pit on 2.6% slope (R2). In the case of terracing and crescent bunding, the maximum peak run-off was 5.3 l/s (19% slope, R3) and minimum was 4 l/s (5% slope, R1) and for terracing and staggered trenching it was 4.6 l/s (10% slope, R3 and R4) and 4 l/s (5% slope, R1) respectively. Control plot had a maximum peak run off of 5.1 l/s (17% slope, R4) and minimum of 4.7 l/s (11% slope, R2). Reduction in the soil moisture content to an extent of 3 to 5% in the upper layer and 1 to 2 % in the deeper layers in all the treatments was observed in the month of January. Maximum soil moisture content inside the trenches and on the sides of the trenches was observed. Maximum soil moisture availability was observed within 1.5 m radius of the plant in the case of crescent bunding and least in the case of control plot.

2.5 Influence of fertigation on yield and quality of cashew.

The trial was laid out during November 2000 under high density planting system and normal tree density system. For high density system three year old Goa 11/6 cashew grafts were used and for normal tree density 10 year old grafts of VRI-1 variety were used.

Design	:	Split plot design
Replication	:	4

Main plot treatments (14)

Different proportion of fertilizers were applied through fertigation system which included 50 and 100% recommended doses of fertilizers.

Sub plot treatments

Irrigating plants @20, 40, 60% of cumulative pan evaporation.

2.5.1 Objectives

i) Working out optimum quantity of fertilizers to be applied through drip system for yield maximization under normal and high tree density systems.

ii) Working out water requirement based on cumulative pan evaporation.

iii) Assessing the effect of fertigation and combinations of fertilizers and organic manuring under normal and high density planting systems on yield.

iv) Assessing the kernel quality for proteins, starch, sugars and fat.

2.5.2 Experiment No.1

Normal tree density (200 trees/ha)

Design : Split plot

Treatments

Main plots : 12

M-1 : 500 g N, 125 g P_2O_5, 125 g K_2O/plant applied through drip irrigation.

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

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

M-4 : 750 g N, 188 g P_2O_5, 188 g K_2O/plant applied through drip irrigation.

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

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

M-7 : 500 g N, 125 g P_2O_5, 125 g K_2O/plant soil application with drip irrigation.

M-8 : 750 g N, 188 g P_2O_5, 188 g K_2O/plant soil application with drip irrigation.

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).

M-11 and M-12 : 50% of M-8 through inorganic (soil application) and 50% through organ (Neem and Castor cak respectively).

M-13 : Control (No irrigation ar fertigation)

Sub plots : 3

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

I-2 : Drip irrigation-40% of CPE

I-3 : Drip irrigation-60% of CPE

Variety used : 10 year old VRI-1 planted a 7m x 7m spacing

2.5.3 Experiment No.2

High tree density (625/ha)

Design : Split plot

Treatments

Main plots : 12

M-1 : 250 g N, 62.5 g P_2O_5, 62.5 g K_2O/plant applied through drip irrigation.

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

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

M-4 : 500 g N, 125 g P_2O_5, 125 g K_2O/plant applied through drip irrigation.

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

M-6 : 50% of above nutrients through drip irrigation and remaining 50% through soil

application in the form of castor cake.

M-7 : 250 g N, 62.5 g P_2O_5, 62.5 g K_2O/plant soil application with drip irrigation.

M-8 : 500 g N, 125 g P_2O_5, 125 g K_2O/plant soil application with drip irrigation.

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).

M-11 and M-12: 50% of M-8 through inorganic (soil application) and 50% through organic (Neem and Castor cakes respectively).

M-13 : No irrigation and fertigation

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 : Four year old Goa 11/6 grafts planted at 4m x 4m spacing.

The first harvest of nuts (2001) indicated no significant difference in yield among the different treatments. Different manurial and irrigation treatments did not have any significant influence on growth characteristics like girth, height, spread, and canopy height of trees.

2.6: Developing integrated production packages for enhancing productivity of cashew (NATP)

The main objectives of the progrmames are nutrient budgeting in high density planting system and developing organic farming technology for utilization of recyclable biomass in cashew orchard.

2.6.1: Nutrient requirement studies in high density planting.

Planting material : Four year old Goa 11/6 grafts
Spacing : 4 m x 4 m
Design : RBD
Replications : 5

Treatments:

(i) No fertilizer application

(ii) Application of fertilizers at 1/3 rd of the recommended dose (250 g N, 50 g each of P_2O_5 and K_2O)

(iii) Application of fertilizers at 1/2 of the recommended dose (375 g N, 75 g each of P_2O_5 and K_2O)

(iv) Application of fertilizers at full dose (750 g N, 150 g each of P_2O_5 and K_2O)

Significant difference in total recyclable biomass collected so far from plots receiving different doses of fertilizer was not observed. Organically recyclable biomass was collected and average dry weight/plant of four year old was 5.4 kg. Differences in yield for different fertilizer dose treatments was not observed. The soil is generally sandy and clay loam. N (< 250 kg/ha) and K (< 100 kg/ha) are low and P (20 to 30 kg/ha) is in medium to high level.

2.6.2 Cashew based cropping system.

(i) Cashew with green manuring crops

Design : RBD
Treatments : 5
Replications : 5

Cashew with sunhemp
Cashew with sesbania
Cashew with glyricidia
Cashew with cover crop
Cashew alone

(ii) Cashew with other crops

Design : RBD
Treatments : 5
Replications : 5

Cashew with groundnut
Cashew with turmeric
Cashew with cowpea
Cashew with pineapple
Cashew alone

Cowpea as an intercrop with cashew

Green biomass obtained from sesbania was 6 t/ha whereas, it was only 3 t/ha in the case of sunhemp. Turmeric and cowpea yields were low. Turmeric yield was 3.35 t rhizomes/ha fetching a total income of Rs. 67,000/ha from intercrop alone. Total expenditure incurred was Rs. 30,920 fetching a net profit of Rs. 36,080/ha. In the case of cowpea, yield realised was only 1320 kg dry seeds/ha. The total cost of cultivation was Rs. 18,000/ha and total income realised was only Rs. 26,000, resulting in a net profit of Rs. 8,000/ha.

2.6.3 **Composting of recyclable biomass**

Design : RBD

Treatments : 8

Replications : 3

a) Composting of recyclable biomass in compost pits

Treatments :

(i) Recyclable biomass

(ii) Recyclable biomass + application of cowdung slurry at 10% of total weight of recyclable biomass

(iii) Recyclable biomass + application of cowdung slurry at 20% of total weight of recyclable biomass

(iv) Recyclable biomass + application of urea solution (0.5%)

(v) Recyclable biomass + 1.25 kg rock phosphate/100 kg of cashew waste

(vi) Recyclable biomass + Urea 0.5% + 1.25 kg rock phosphate/100 kg of cashew waste

(vii) Recyclable biomass + cowdung slurry (10%) + 1.25 kg rock phosphate/100 kg of recyclable biomass.

(viii) Recyclable biomass + P solubilizing organism – application of cowdung slurry at 10% of total weight of recyclable biomass.

Japanese compost chambers of size 2m (l) x 1m (b) x 0.75m (h) were used for above studies.

It was observed that six months after imposing treatments the treatment of recyclable biomass + urea (0.5%) and recyclable biomass – urea (0.5%) + 1.25 kg rock phosphate gave minimum C/N ratio of 12.3 and 12.2 compared to 19.9 to 22.0 in other treatments respectively (Table 2.8). P concentrations were twice

Table 2.8: Organic carbon (OC), N, P and C/N ratio in recyclable biomass of cashew orchard six months after treatment

Treatments	%			
	OC	N	P	C/N
RB alone	25.2	1.20	0.50	21.0
RB + 10% CD	30.6	1.39	0.50	22.0
RB + 20% CD	35.2	1.60	0.55	22.0
RB + U (0.5%)	25.7	2.10	0.50	12.3
RB + RP (1.25 kg /100 kg biomass)	25.9	1.30	0.90	19.9
RB + U (0.5%) + RP (1.25 kg/100 kg biomass)	26.3	2.20	0.99	12.2
RB + 10% CD + RP (1.25 kg/100 kg biomass)	29.9	1.40	0.95	21.9

RB – Recyclable biomass, CD – Cowdung, U – Urea solution, RP – Rock phosphate

Table 2.9: Colony forming units of microrganism in recyclable biomass subjected to different treatments for production of compost.

Treatments	Bacteria ($x10^6$)	Fungi ($x10^4$)	Actinomycetes ($x10^5$)
RB alone	13	23	0.8
RB + 10% CD	18	20	1.2
RB + 20% CD	21	23	12.0
RB + U (0.5%)	11	25	0.8
RB + RP (1.25 kg /100 kg biomass)	20	38	15.0
RB + U (0.5%) + RP (1.25 kg/100 kg biomass)	19	18	1.0
RB + 10% CD + RP (1.25 kg/100 kg biomass)	20	20	1.2

RB = Recyclable biomass, CD = Cowdung, U = Urea solution, RP = Rock phosphate

in treatments receiving rock phosphate compared to other treatments without rock phosphate. Maximum colony forming units (cfu) of bacteria were observed in treatment recyclable biomass + 20% cowdung slurry. Minimum was in recyclable biomass alone. Maximum cfu of fungi was found in treatment recyclable biomass + rock phosphate and minimum in recyclable biomass + urea + rock phosphate. Maximum actinomycetes cfu was found in recyclable biomass + rock phosphate treatment (Table 2.9).

b) Vermi compost

Recyclable biomass from cashew garden when treated with cowdung slurry(15% of total weight) could be converted into vermicompost within three months by earthworm (*Eudrilus* sp). Two tons of organically recyclable biomass could be converted into 1.35 tons of vermicompost. Vermicompost thus produced was rich in N (1.2%), P (0.9%), K (0.6%), Ca (2.86%) and micronutrients like Fe (16.2 ppm), Mn (24.5 ppm), Cu (12.4 ppm) and Zn (29.7 ppm).

2.7 Crop regulation in cashew through growth regulators

Studies on crop regulation in cashew was initiated during current fruiting season (2001-02) with an objective of ameliorating specific production constraints associated with certain cashew varieties which were earlier released for cultivation.

2.7.1 Improvement of sex ratio, fruit set and nut retention in cashew

VRI-1 has specific production constraint wherein the plant has prolonged male phase and a shorter mixed phase towards the end of flowering season which in turn results in poor set and development of nuts. In order to enhance the sex ratio and fruit-set, the study was initiated in existing 13 year old cashew plantation at Shantigodu campus. Various growth regulators viz., 2,4-D (5, 10, 15 ppm), IAA and NAA (50, 100 and 150 ppm) and urea (1, 2 and 3%) were sprayed at early flowering (3rd week of October), flowering (3rd week of November) and fruiting (3rd week of December) season of year 2001. For each treatment one tree was sprayed and observed. Each treatment was replicated four times. Thirty panicles were tagged in each tree immediately after the first spray. Observations on number of male and hermaphrodite flowers, fruit-set and nut retention were recorded at weekly intervals. 2,4-D at 10 and 15 ppm caused burning of flower panicles due to phytotoxicity if sprayed at early flushing season. Observations on the number of male and bisexual flowers by destructive sampling indicated that dominant male phase continued in the early flowering season irrespective of growth regulator treatments. The sex ratio was not influenced by different growth regulator treatments. Similarly the fruit set as well as nut retention also remained unchanged due to the application of growth regulators.

Drying of flower panicles due to phytotoxicity of 2,4-D

2.7.2 Improvement of nutsize through fruit thinning

The study was specifically taken up to improve the nut size of high yielding cashew varieties with small nut types such as Kanaka, K-22-1, Ullal-2, V-2 and V-5. Five year old plants of Kanaka variety at Shantigodu campus were used for the study. Various growth regulators viz., ethrel (50, 100 and 150 ppm), NAA and GA (100, 200 and 300 ppm) and KNO_3 (0.5, 1.0 and 1.5%) were applied at peak fruiting stage (3rd week of December). For each treatment one tree was taken as a unit and replicated five times. Twentyfive panicles in each tree were tagged and fruit set, fruit drop and final retention, volume and weight were recorded. Among various chemical fruit thinners sprayed, ethrel at 150 ppm during peak fruiting stage (January), caused fruit drop but the corresponding increment in weight or volume of retained nuts could not be observed.

Dryfng of nuts caused by ethrel (150 ppm) applied for fruit thinning

3. CROP PROTECTION

Studies were undertaken to develop pest management techniques under the project IPM for cashew stem and root borers (CSRB). These studies included identification of host plant kairomones, sex pheromones and estimation of age of CSRB grubs. New botanical based insecticides have been evaluated for managing the tea mosquito bug (TMB). Studies on sex pheromones of TMB have also been initiated. Protocols have been standardized for determination of residues in kernels for the commonly used insecticides in the management of pests of cashew.

3.1 Cashew Stem and Root Borer (CSRB)

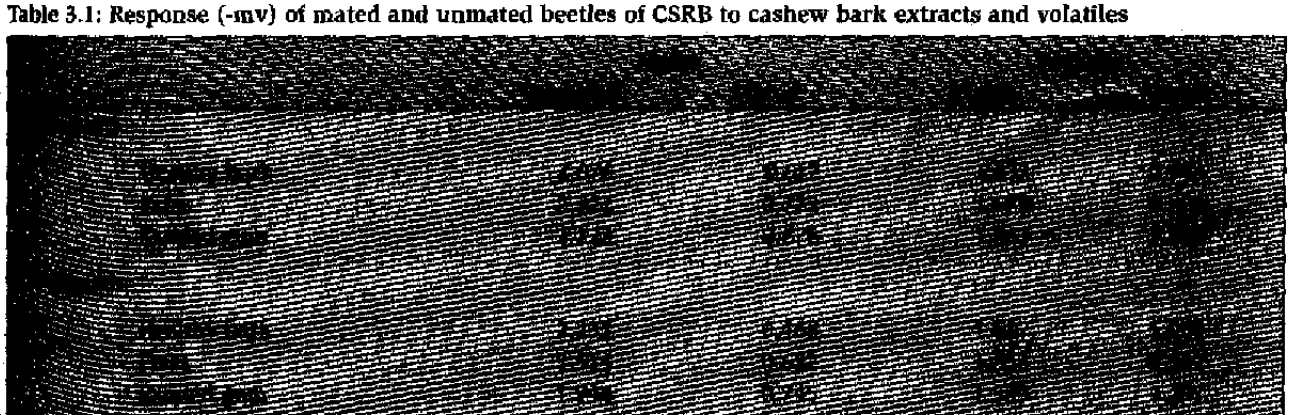
3.1.1 Kairomones

Various plant parts such as healthy bark, fresh frass and exuded gum were used for extraction and collection of volatiles in n-hexane. Extracts and volatiles after concentration were evaluated in Electroantennogram (EAG) for response induction from mated and unmated beetles of both sexes. Mean response was highest in the case of unmated males followed by virgin females. Further among mated beetles, mated females responded more compared to mated males. This supports the field observations wherein re-infestation and repeated egg laying occurs in the trees having frass accumulation along with exuded gum.The responses were on par for extracts and volatiles of all the three test materials viz., healthy bark, frass and exuded gum (Table 3.1).

3.1.2 Sex pheromones

The different body parts which normally bear the pheromonal appendages in coleopterans (beetles) viz., base of elytra (hardened forewing), thorax and

Table 3.1: Response (-mv) of mated and unmated beetles of CSRB to cashew bark extracts and volatiles



Statistical Inference	
a) Sex group	
Unmated males	2.119 a
Mated males	0.647 d
Virgin females	1.701 b
Mated females	1.008 c
b) Test material	
Extracts	1.391
Volatiles	1.347
	NS
c) Plant source	
Healthy bark	1.345
Frass	1.372
Exuded gum	1.388
	NS

Values followed by different alphabets are statistically significant.

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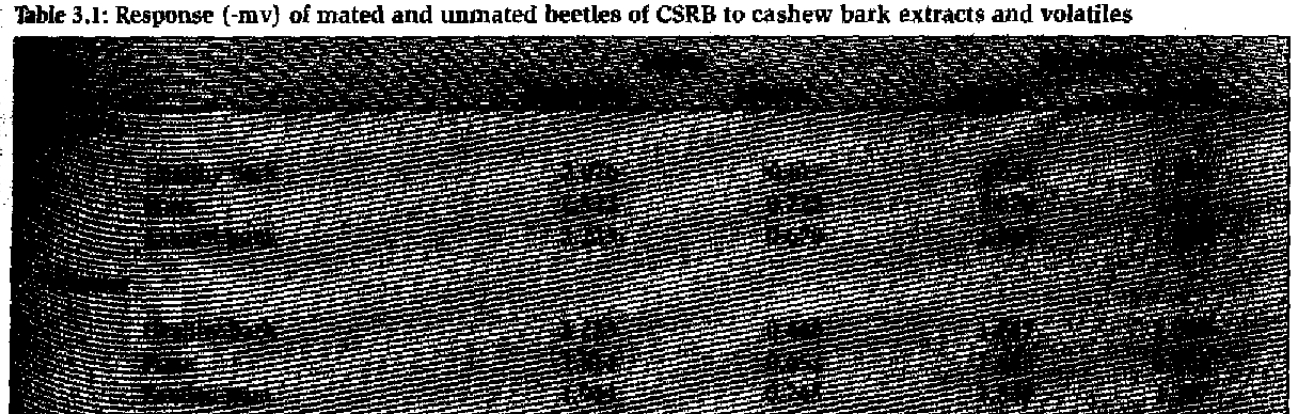

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	NS
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Healthy bark	1.345
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	NS

Values followed by different alphabets are statistically significant.

abdominal tip of mated and unmated beetles of both sexes were extracted in n-hexane at 6-10°C for 48 h. These extracts after concentration were evaluated for response induction by EAG (Table 3.2).

Among the sex groups, virgin females followed by mated females exhibited highest response. The unmated and mated males displayed significantly lesser response to all extracts from different parts of the various sex groups. The response exhibited by any sex group was statistically non-significant for different body part extracts from the four different sex group (Table 3.2). The response of both sexes to extracts o opposite and same sex indicate the possibility o presence of dual sex pheromone/aggregation pheromone.

3.1.3 Estimation of age of CSRB grubs

The biometrics of laboratory reared CSRB grubs at 15 days intervals was done for the head capsul (HC) and pro-thoracic shield (PTS) width. The ag

Table 3.2: EAG response (-mv) of different sex groups of CSRB to extracts from different body parts of adul CSRB.

Extracts		Males		Females	
		Mated	Unmated	Virgin	Mated
[illegible]	[illegible]	0.727	[illegible]	[illegible]	0.825
	Thorax	[illegible]	[illegible]	[illegible]	[illegible]
	Base of elytra	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Abdominal tip	[illegible]	[illegible]	[illegible]	[illegible]
	Thorax	0.676	0.729	[illegible]	0.710
	Base of elytra	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Statistical Inference

[illegible]	[illegible]
a) Sex group	0.751 c
Unmated males	0.697 d
Mated males	1.363 a
Virgin females	0.755 b
Mated females	
b) Body parts extracted	
Abdominal tip	0.872
Thorax	0.877
Base of elytra	0.925
	NS
c) Sex of source insect	
Unmated males	0.941
Mated males	0.893
Virgin females	0.831
Mated females	0.901
	NS

Values followed by different alphabets are statistically significant.

estimation was attempted using HC and PTS widths. The main constraint in measuring the HC width was that the CSRB grubs immediately withdrew the head capusule when held by callipers. This led to physical damage of the pleural membrane leading to mortality of such grubs. The differences in the PTS width for different age groups of CSRB grubs was more evident than the slight differences occurring in the HC width. Hence PTS width as an estimate of age of field collected grubs was more practicable.

3.1.4 Rearing of CSRB on semi-synthetic diet (SSD)

CSRB grubs were reared upto adult stage on SSD and compared with rearing on host bark. The life cycle was completed in 295 days on SSD while it was 335 days on host bark. Survival upto adulthood was 64% on SSD as compared to 60% on host bark (Table 3.3). The results indicated that in the case of host bark non-availability, SSD can be used as an alternative for laboratory rearing of CSRB.

Table 3.3: Life cycle of CRSB on host bark and semi synthetic diet.

Parameters	Semi-synthetic diet	Host bark
Larval period (days)	168	206
Pupal period (days)	127	129
% survival upto adult stage	64	60
Longevity of adult male (days)	14.8	14.6
Longevity of adult female (days)	23.0	23.0
Adult body length (cm)	2.9	3.0

3.1.5 Evaluation of *Metarhizium anisopliae*

M. anisopliae was evaluated as prophylactic method against the pest infestation using cashew apple and broken rice grain as substrates. The spawn was mixed with the substrates and applied to soil at 250 g/ tree. Infestation occurred on tree which had earlier attack, inspite of *M. anisopliae* treatment (20.8%) and in untreated plot 16.7% fresh infestation was noticed. Eventhough entomopathogen from soil sampled after four months of spawn application induced 74.1% mortality of CSRB grubs in the laboratory, it could not cause mycosis under field condition.

3.1.6 Use of hormones to aid recovery of CSRB infested trees

CSRB infested trees were treated with different hormones viz., IAA, NAA, IBA and 2,4-D (all at 200 ppm) to enhance bark regrowth and induce rooting.

Root development after IBA treatment in a CSRB infested tree

Contiguous bark callus formation was noticed in IAA and NAA treatments. IBA induced root development which achieved thickness of about one cm in 30-45 days after application. 2,4-D induced low degree of patchy bark callus.

3.2 Tea Mosquito Bug (TMB)

3.2.1 Chemical control

A) Field trials

From earlier evaluation trials, λ-cyhalothrin and imidachloprid were found to be promising. Therefore, these two insecticides were evaluated with recommended insecticides (monocrotophos, and carbaryl) in an exploded block design with single replication. For each treatment, two rows with six trees each were selected. In each tree, half of the canopy on the inner side of row was treated and the outer side of canopy was left untreated. Three rounds of sprays of each treatment was given during first week of December, January and February. The damage (0-4 grade) was assessed before each spray and one month

Table 3.4: Evaluation of promising insecticides against TMB in large plot trial.

Treatments	TMB Damage (0-4 scale 10 days after third spray)	Predators (No./panicle)	
		Spider	Total predator
Monocrotophos 0.05%	[illegible] b, d	[illegible]	0.17 b
Carbaryl 0.1%	0.44 a, d	[illegible]	0.37 b, c
λ Cyhalothrin 0.003%	0.44 a-d	[illegible]	0.19 b
λ Cyhalothrin 0.004%	0.54 a, d	[illegible]	0.12 b
Imidacloprid 0.01%	2.31 a, c	[illegible]	0.27 b, c
Untreated control	3.40 b	[illegible] a	0.71 a

By paired 't' test a vs b is significant; c vs c is not significant; d vs d is not significant

after third spray. The predator population (spider, ants, mirid, reduviid and geocorid bugs, preying mantids and chrysopids) existing on 52 panicles/tree was recorded by tapping the panicle on one square foot cardboard sheet on 10th day after third spray. The results were compared through paired 't' test and all the insecticides were found to be superior than untreated control. However, among all insecticides, carbaryl, λ-cyhalothrin and monocrotophos were superior than imidacloprid. Even though, all insecticidal treatments recorded comparatively lower population of spider and total predatory fauna, carbaryl and imidacloprid recorded significantly highest population of total predatory fauna than other insecticides (Table 3.4).

B) Laboratory studies with new insecticides

(i) Evaluation of newer insecticide against TMB for residual toxicity

Insecticides were sprayed on the cashew seedlings with tender leaves. The tea mosquito bug (TMB) nymphs were caged on to these seedlings on same day, third day and seventh day after spraying @ 6 insects/cage. The survival of TMB was recorded 24h after caging. The damage to the seedlings was recorded using 0-4 scale. The results are presented in Table 3.5 and 3.6. The results indicated that cartap hydrochloride showed higher residual action against late instar TMB nymphs and adults. The results were comparable with carbaryl (0.1%). GB+ did not possess residual toxicity against TMB. The damage score was also lower in the case of cartap hydrochloride.

(ii) Effect of insecticides on oviposition of TMB

Gravid females were released on cashew seedlings treated with insecticides on same day, three days and seven days after treatment to find out the effect on oviposition. The results are presented in Table 3.7. The eggs laid were less in both carbaryl and cartap hydrochloride compared to untreated check.

(iii) Ovicidal action and residual action against first instar nymphs

TMB eggs were collected in cashew seedlings by caging gravid females. Insecticides were sprayed

Table 3.5: Residual toxicity of new insecticides on survival of TMB.

Treatments	No. survived after 24 h after caging on		
	Same day	3rd day	7th day
Cartap hydrochloride (0.025%)	0 (0.71)aA	0 (0.71)aA	0.67 (1.08)aB
GB+ (0.5%)	6.0 (2.55)bA	6.0 (2.55)bA	6.0 (2.55)bA
Carbaryl (0.1%)	0 (0.71)aA	0 (0.71)aA	0 (0.71)aA
Control (Untreated check)	6.0 (2.55)bA	6.0 (2.55)bA	6.0 (2.55)bA

Figures in parentheses are transformed ($\sqrt{x+0.5}$) values

Mean followed by common small letter in each column and common big letter in each row is not significantly different at 5% level of significance.

3.6: Damage grade in different insecticides 48 h after caging.

Treatments	Damage grade (0-4 scale) 48 h after caging on		
	Same day	3rd day	7th day
...rbaryl (0.075%)	0.83 (1.51)bA	1.50 (1.41)bA	1.67 (1.47)aA
	2.83 (1.82)cA	3.0 (1.87)cA	3.20 (1.92)bA
...%)	0.50 (1.00)aA	0.50 (1.00)aA	1.67 (1.47)aB
...ated check)	3.33 (1.95)cA	3.67 (2.04)cA	3.30 (1.95)bA

Figures in parentheses are transformed $(\sqrt{x+0.5})$ values

...followed by common small letter in each column and common big letter in each row is not significantly different at 5% ...l of significance.

3.7: Effect of insecticides on oviposition.

	No. of eggs/shoot/5 days Caged for		
	Same day	3rd day	7th day
...rbaryl (0.075%)	1.4 (1.37)aA	1.4 (1.37)aA	1.4 (1.37)aB
	12.2 (3.56)bA	15.5 (4.53)bA	10.3 (3.29)bA
...%)	3.2 (1.92)aA	1.8 (1.52)aA	2.8 (1.82)aA
...ated check)	18.0 (4.30)cA	19.4 (4.94)bA	17.4 (4.23)cA

Figures in parantheses are transformed $(\sqrt{x+0.5})$ values

...followed by common small letter in each column and common big letter in each row is not significantly different at ...level of significance.

...these seedlings individually to find out ovicidal ...n and residual action against first instar nymphs. ...ltaneously, healthy undamaged seedlings having ...r flushes were also treated with same insecticides. ...laden and healthy treated cashew seedlings of ...ective treatment were tied together. The newly ...ed nymphs can migrate and feed on tender flushes ...ealthy treated cashew seedlings. The damage was ...ed on third day after hatching of nymphs. The ...nt of hatching of eggs was estimated from TMB ...laden seedlings on fifth day of hatching. The results ...presented in Table 3.8. The insecticides evaluated ...not inhibit the hatchability of eggs. The damage ...first instar nymphs was very low for cartap ...rochloride which was on par with carbaryl ...%).

Evaluation of spreading agent Apsa 80

Insecticides (Table 3.9) were evaluated against ... under field condition in an exploded block design. ... 80 a spreading agent (spray adjuvant) was also ...luated after mixing with carbaryl (0.1%). For each ...ment, two rows of four trees each were selected. ...ree sprays were given at flushing (Oct. 2001), flowering (Nov. 2001) and fruiting (Dec. 2001). TMB population was generally low during the season. However, damage (0-4 scale) was assessed before each spray and one month after third spray. The results were compared through 't' test. The damage grade was lower in carbaryl, carbaryl + Apsa 80 followed by cartap hydrochloride. All these treatments were on par and superior to GB + and untreated control.

The quantity of spray solution required for each treatment was also worked out which was lowest for carbaryl + Apsa 80 combination. Economics of carbaryl alone and carbaryl + Apsa 80 was worked out (Table 3.10). There was reduction in spray solution requirement by 33.18%. After taking into consideration the cost involved for Apsa 80, the total expenditure for spraying was reduced by 19.17%. Mixing of Apsa 80 with carbaryl provided more uniform spray deposit on crop canopy and so improved the coverage.

3.2.2 Biological control

A) Predators

The population of spider and total predatory fauna was recorded from 52 panicles/tree by tapping

Table 3.8: Effect of new insecticides on hatching of eggs and damage by first instar nymphs of TMB.

Treatments	No. of eggs	No. hatched	%	Damage grade 1st instar nymp
Cartap hydrochloride (0.075%)	66	61	92.4	0.6 (1.05)a
GB + (0.4%)	81	72	88.8	3.0 (1.87)b
Carbaryl (0.1%)	76	71	93.4	0.2 (0.83)a
Control	80	76	95.0	3.4 (1.97)b

Figures in parantheses are transformed $(\sqrt{x+0.5})$values

Mean followed by common small letter in column is not significantly different at 5% level of significance

Table 3.9: Evaluation of newer insecticides and Apsa 80.

Treatments	Damage [illegible]	Average spray solution/tree/spray (l)
Cartap hydrochloride (0.075%)	[illegible]	5.96
GB + (0.4%)	[illegible]	4.17
Carbaryl (0.1%) + Apsa 80 (5 ml/15 l)	[illegible]	2.92
Carbaryl (0.1%)	[illegible]	4.37
Control	[illegible]	[illegible]

By 't' test a versus b is significant

Table 3.10: Economics of carbaryl (0.1%) and carbaryl (0.1%) + Apsa80

Treatments	Quantity of spray solution (l)	Quantity of Carbaryl (g)	Cost (Rs)	Quantity of Apsa (ml)	Cost (Rs)	Total Cost (Rs)
Carbaryl (0.1%)	4.37	8.74	3.50	-	-	3.50
Carbaryl (0.1%) + Apsa 80 (5 ml/15 l)	2.92	5.84	2.33	0.96	0.48	2.81

Carbaryl - Rs. 400/kg ; Apsa 80 - Rs. 500/l

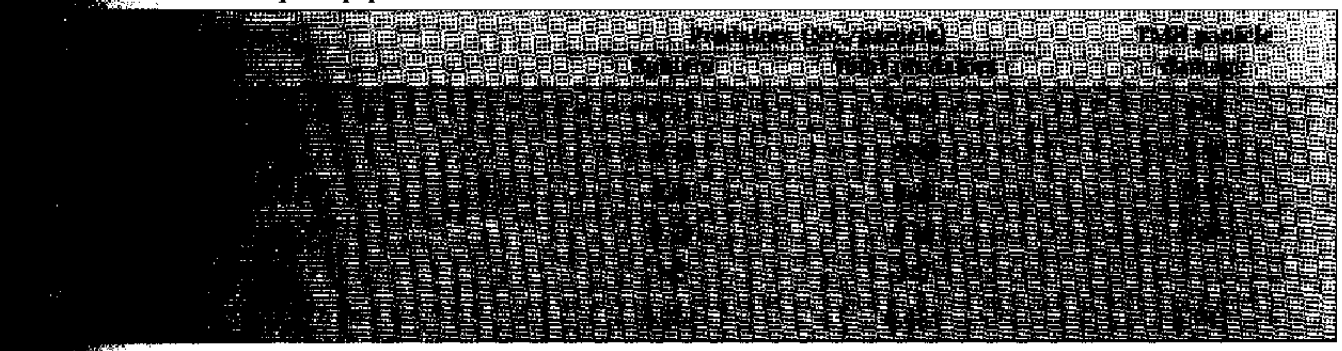
Reduction in expenditure : 19.71% Reduction in spray solution requirement : 33.18%

method at four locations without any insecticidal spray at Vittal and Shantigodu cashew plantations. In each location 12 trees selected at random were observed during flowering period. The results indicated that no significant variation was recorded with respect to the population of spider and total predators among different locations. No significant relationship was observed between extent of TMB damage and population of spider or total predator. Therefore their role in the sustainable suppression of TMB was found to be insignificant. However, there was significant positive relationship between the population of spider and total predators indicating positive co-existence cashew ecosystem (Table 3.11).

B) Parasitoids

The eggs of TMB were exposed at week intervals for three years (1997-2000) for parasitisati by its egg parasitoids under natural condition as he enrichment technique (HET). The percentage of e parasitism and percentage of relative emergence adult parasitoids on thirtieth day of exposure we correlated with weather factors. The results reveal that the occurrence of egg parasitoids due to tw species of solitary egg parasitoids (*Telenomus* sp. ar

3.11: Effect of spider population on outbreak of TMB.



- Non significant
- Damage versus spiders / total predators relationship non significant (r = 0.420)
- Damage versus spiders / total predators relationship non significant (r = 0.203 / 0.135)

3.12: Characteristics of biological control of *H. antonii* by its egg parasitoids studied under HET.

	a	b
...g. vs. *Chaetostricha* sp.	-0.4497** (-0.2265*)	0.5140** (-0.1916*)
...density vs % egg parasitism	0.1971*	-0.0199 NS
...of key factor analysis (k values vs log no. of ...)	0.1956*	0.0283 NS
...parasitism vs % relative emergence of adult parasitoid	(0.1880*)	
i) For *Telenomus* sp.	0.2927**	0.0480 NS
ii) For *Chaetostricha* sp.	0.4363**	0.6452**

- Correlation coefficient values ('r') pertaining to whole year (October - September).
- Correlation coefficient values ('r') pertaining to vulnerable period of crop (last week of November to second week of February)
- Significant at P = 0.05
- Significant at P-0.01
- Non significant
- Natural parasitism recorded in the field
- Vulnerable period excluded

Chaetostricha sp.) was confirmed and both species exhibited negative relationship. The percentage of egg parasitism was positively related with host egg density during whole year of study indicating the direct density dependent relationship and it was with lack of correlation during vulnerable period of the crop (last week of November and second week of February).

In the case of key factor analysis, regression coefficient ('b' value) was significant during vulnerable period of crop. During whole year of study it was not significant during vulnerable period of crop. In the whole year of study, when vulnerable period of crop was excluded, the regression coefficient was also significant and positively related (Table 3.12). The positive relationship indicated that mortality of TMB due to egg parasitism was density dependent. However, during vulnerable period of crop, instability in parasitoid and host relationship was noticed and it may lead to outbreak of TMB.

The relationship of weather parameters on % egg parasitism and relative emergence of adult parasitoids is presented in Table 3.13. Among weather factors, minimum temperature and its related factors exert negative influence, whereas, minimum temperature especially during vulnerable period of crop influences positively on % egg parasitism.

3.2.3 Varietal resistance

TMB population on TMB escape accession (Goa 11/6) was monitored during 2000-2001 cropping season. The build up of population was observed from second fortnight of December 2000 and continued upto

Table 3.13 : Relationship of weather factors on % egg parasitism and % relative emergence of adult parasitoid under HET.

Weather factors	% egg parasitism		% relative emergence of adult parasitoids on [illegible] DAE			
			Telenomus sp.		*Chaetostricha* sp.	
	A	B	A	B	A	B
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

A Correlation coefficient values ('r') pertaining to whole year

B Correlation coefficient values ('r') pertaining to vulnerable period

DAE Days after exposure of host eggs

NS Non significant

* Significant at P = 0.05

** Significant at P = 0.01

Feburary 2001 and declined from March onwards. As a result, moderate to severe infestation of TMB was recorded. Even, under this situation, an yield of 1.82 t/ha with a range of 2.1 to 12.9 kg/tree was recorded.

3.3: Studies on determination of insecticide residues in kernels

3.3.1 Standardisation of protocol

A) Carbaryl

A protocol has been standardised for determination of carbary residue. Carbaryl was hydrolized with alkali and the resulting l-naphthol was reacted with pyridine and trichloroacetyl chloride to produce trichloroacetate which was analysed by (ECD) gas chromatograph. The column, injection port and detector temperature suitable were 180°C, 220°C and 240°C respectively. The flow of carrier gas (N_2) was 25 ml/min. The carbaryl content was determined by comparing with response for a known standard of similar concentration. The recovery of the residue was 78.27% by this method.

B) Chlorpyriphos

For extraction of residues, kernel sample was extracted with n-hexane and partitioned with acetonitrile. The acetonitrile layer was concentrated and again partitioned to n-hexane. This was dried over anhydrous sodium sulphate and concentrated. The residue after dissolving in 10 ml of n-hexane was purified by passing through silicagel column and elution with n-hexane. This was analysed by gas chromatography. The injector, column and detector temperatures are 250°C, 190°C and 240°C respectively. The flow of carrier gas (N_2) was 30 ml/min. The recovery of the residues was 80.27% by following this method.

3.3.2 Determination of levels of different insecticides used in the management of tea mosquito bug

A) Endosulfan

Endosulfan was sprayed at recommended concentration (0.05%) and double the recommended concentration (0.1%) to the cashew trees at fruiting stage. Nuts were collected 3, 7 and 14 days after treatment and the kernels were analysed for the residues. Residue was not detected in the kernels.

B) Carbaryl

Carbaryl was sprayed at recommended

concentration (0.1%) and double the recommended concentration (0.2%) to the cashew trees at fruiting stages. Nuts were collected 3, 7 and 14 days after treatments and the kernels were analysed for the residues. Residues were not detected in the kernels.

3.3.3 Insecticide residue in the samples from farmers' fields and farm gate (market) samples

Rawnuts were collected from farmers' fields of Dakshina Kannada district and analysed for the residues of endosulfan and carbaryl. Residues were not detected in kernels of 15 samples analysed. Samples were also collected at farm gate and analysed for the residues of endosufaln and carbaryl. In the 15 samples collected from Dakshina Kannada district, residues of these insecticides were not traced in kernels.

3.4: Studies on pheromones of tea mosquito bug (*Helopeltis antonii*)

3.4.1 Standardisation of testing conditions for Electroantennogram studies

The antenna from male insect was separated and tested under Electroantennogram (EAG) for the response for various extracts. The antenna responded for a maximum period of 35 min after separation from the insect. The maximum response was between 5 and 25 min and so the testing of the extracts should be done during this period for better results.

3.4.2 Preparation of extracts

Whole body, abdomen and thoracic parts of adult female bugs of tea mosquito bugs were extracted with n-hexane, dichloromethane and petroleum ether. For preparation of the extract, whole body or the body part of the insect was macerated using respective solvents and extracted at 4°C for 48 h. The extract was filtered and concentrated. For each extract 25 adult female bugs were used. The extracts were stored at 4°C till EAG studies.

3.4.3 Response of the male antennae to the extracts

The extracts prepared were tested using Electroantennogram (EAG) for the response from male TMB. The response was higher for the whole body extracts in dichloromethane (-0.813 mv) compared to -0.275 mv for dichloromethane alone. Whole body extract in petroleum ether also elicited higher response (-0.703 mv) compared to -0.408 mv when petroleum ether was tested alone.

4. POST - HARVEST TECHNOLOGY

4.1 Value addition in cashew

4.1.1 Storage studies of coated baby bits

Whole and defatted cashew kernel baby bits after coating with cane sugar and different flavours such as vanillin, cardamom and ginger essential oils were evaluated for organoleptic acceptability during storage (Table 4.1). Results presented indicates that sweetened and flavoured cashew kernel baby bits could be stored in sealed polythene pouches (300 gauge) at ambient temperature (30°C) upto eight months without any quality deterioration.

Possibility of coating baby bits with permitted colours was explored (Table 4.2) of colours at 0.1% concentration was attem and without cane sugar. Extent of coating o colours was less in the presence of cane suga kernel baby bits were coated with different varying concentration of cane sugar (Table 4. of coating of colours was inversely proportio concentration of sugar. These results indi colours and cane sugar compete with each oth coating of baby bits.

Table 4.1: Sensory evaluation of coated baby bits during storage at ambient temperature

Storage period (Months)		Whole Baby Bits			Defatted Baby Bits		
		MCH	Sugar coating (%)	Peroxides (meq/kg MDA / 100g)	MCH	Sugar coating (%)	P
0	A	13.50	12.40	1.62	16.80	18.20	
	B	13.20	10.10	1.76	14.70	30.30	
	C	15.60	12.40	1.56	14.30	16.20	
	D	13.30	10.90	1.79	14.20	19.35	
2	A	14.40	8.10	1.30	19.20	18.10	
	B	13.80	4.90	1.38	14.10	29.96	
	C	13.60	4.60	1.20	14.20	22.62	
	D	13.90	5.50	1.16	15.67	16.45	
4	A	15.10	11.13	0.53	17.13	17.82	
	B	13.82	8.45	0.44	13.33	28.86	
	C	14.29	9.92	0.57	13.60	17.21	
	D	13.65	8.4	0.55	13.60	22.62	
6	A	14.00	7.93	1.28	19.56	19.64	
	B	12.95	12.83	1.62	14.69	29.16	
	C	14.05	11.25	1.05	14.87	22.34	
	D	13.47	9.68	1.08	15.06	27.74	
8	A	14.47	8.68	1.41	19.60	15.77	
	B	12.29	12.29	1.75	15.14	22.33	
	C	13.18	8.50	1.40	13.78	12.41	
	D	14.41	6.70	1.47	15.14	17.92	

Values for % coating are mean of two estimations. Values for peroxides are mean of three estimations. MCH value repre the mean of cumulative hedonic score for colour, flavour, texture and taste of 15 judges.

A - Baby bits coated with 70% cane sugar.
B - Baby bits coated with 70% cane sugar containing 0.1% vanillin
C - Baby bits coated with 70% cane sugar containing 0.1% cardamom essential oil.
D - Baby bits coated with 70% cane sugar containing 0.1% ginger essential oil.

Table 4.2: Coating of baby bits with different colours in distilled water and 70% cane sugar solution.

Colours	% Coating			
	Colour		Cane sugar	
	Water	70% cane sugar	Water	70% cane sugar
Apple green (IH 8925)	0.155	0.068		19.26
Chocolate brown (IH 8926)	0.075	0.041		28.32
Saffron powder (IH 9140)	0.068	0.036		17.66
Lemon yellow (IH 6597)	0.064	0.047		25.42
Orange red (IH 7802)	0.092	0.023		17.14
Raspberry red (IH 7804)	0.04	0.016		13.67
70% cane sugar (control)				34.08

Baby bits were coated at 100°C for 5 min. Ratio of baby bits to coating solution was 1:2. For coating, colours at 0.1% concentration was dissolved either in distilled water or 70% cane sugar solution. Coated baby bits were extracted at 10°C for 12 h and absorbance was read after centrifugation for determining the % coating of colour. Similarly % coating of cane sugar was assessed by determining the total sugar in the extracts of coated baby bits. Values are the mean of four individual estimations.

CD ($p = 0.01$) for % coating of colour with and without 70% cane sugar = 0.01

CD ($p = 0.01$) for % coating of different colours with and without 70% cane sugar = 0.0066

CD ($p = 0.01$) for % coating of cane sugar with and without colour = 6.00

Table 4.3: Coating of cashew kernel baby bits with colours at varying concentration of cane sugar.

Cane sugar concentration (%)	% coating			
	Apple green		Raspberry Red	
	Colour	Sugar	Colour	Sugar
0	0.09		0.040	
30	0.053	10.10	0.029	6.04
40	0.043	11.45	0.030	9.82
50	0.037	11.75	0.025	11.78
60	0.032	13.74	0.021	11.92
70	0.034	14.34	0.017	12.37
CD ($p = 0.01$)	0.007	2.27	0.0076	2.16

Whole cashew kernel baby bits were coated with different combination of colour and flavour and organoleptically evaluated (Table 4.4). Irrespective of flavour, raspberry red coated baby bits are least preferred while cardamom essential oil and saffron coated baby bits are most preferred. Similar studies were conducted with honey coated baby bits. Even with honey coated baby bits, raspberry red coated baby bits are least preferred irrespective of the flavour. Baby bits coated with honey, cardamom essential oil and apple green colour are most preferred (Table 4.5).

Whole cashew kernel baby bits and defatted cashew kernel baby bits were coated with clarified cashew apple juice and cashew apple aroma distillate and organoleptically evaluated. Organoleptic acceptability of cashew apple juice and aroma distillate coated baby bits could be improved by the inclusion of cane sugar while coating (Table 4.6).

4.1.2 Preparation of fibre rich cereal / pulses blends

In order to develop fibre rich blends, rice, ragi and wheat flour (60%), green gram flour (20-40%)

Table 4.4: Sensory evaluation (MCH values) of cashew kernel baby bits coated with sugar and different combina of colour and flavours.

Flavour / Colour	Control	Vanillin	Cardamom	Ginger	Clove	Mean
Apple green	13.67	13.20	12.73	13.00	12.73	13.06
Chocolate brown	15.60	13.53	12.40	14.53	13.53	13.92
Saffron	14.20	12.93	12.00	12.73	13.00	12.97
Lemon yellow	13.73	14.33	13.47	14.00	12.93	13.69
Orange red	13.53	12.13	12.33	12.73	14.47	13.24
Raspberry red	16.27	16.40	16.20	15.80	15.67	16.07
Mean	14.50	13.75	13.35	13.80	13.72	

Whole baby bits are coated with 70% cane sugar, 0.1% of different flavour and colour at 100°C for 5 min

CD for flavour : NS
CD for colour (1%) : 1.45
No of replications : 15

Table 4.5: Sensory evaluation (MCH values) of honey coated baby bits with different combination of flav and colour.

Flavour / Colour	Control	Vanillin	Cardamom	Ginger	Clove	Mea
Apple green	17.13	17.73	13.87	14.40	17.33	16.
Chocolate brown	23.80	17.40	16.80	14.86	14.93	17.
Saffron powder	16.00	14.53	15.07	15.00	14.93	15.
Lemon yellow	14.93	15.73	15.20	15.33	14.60	14.
Orange red	17.26	19.40	15.73	15.46	15.06	16.
Raspberry red	27.52	20.00	16.40	17.40	16.53	18.
Mean	18.50	17.60	15.38	15.24	15.57	

Baby bits were coated with 70% honey containing different colours and flavours at 0.1% concentration at 100°C 5 min. Evaluated for colour, flavour, texture and taste and values of MCH (mean cumulative hedonic score) are mean of judges.

CD for flavour (1%) : 1.26
CD for colour (1%) : 1.59
CD for flavour x colour : 3.81

Table 4.6: Sensory evaluation of cashew apple juice and aroma distillate coated cashew kernel baby bits.

Coating solution	MCH	% Coating
70% sugar	13.25	8.33
Clarified cashew apple juice	20.76	2.17
Cashew apple juice containing 70% sugar	15.56	6.71
Cashew apple aroma distillate	20.35	-
Cashew apple aroma distillate containing 70% sugar	13.46	7.13

Table 4.7: Physical properties of different blends containing cashew apple pomace

Flour blends	Water absorption capacity (g/g)	Consistency		
		1:1	[illegible]	1:2
Rice + G Gram (60:40)	1.157	[illegible]	[illegible]	5.20
Rice + G Gram + Pomace (60:35:5)	1.040	[illegible]	[illegible]	4.87
Rice + G Gram + Pomace (60:30:10)	1.186	[illegible]	[illegible]	8.13
Rice + G Gram + Pomace (60:25:15)	1.502	[illegible]	[illegible]	6.45
Rice + G Gram + Pomace (60:20:20)	1.524	[illegible]	[illegible]	5.65
Wheat + G Gram (60:40)	0.758	[illegible]	[illegible]	8.87
Wheat + G Gram + Pomace (60:35:5)	0.856	[illegible]	[illegible]	8.33
Wheat + G Gram + Pomace (60:30:10)	1.037	[illegible]	[illegible]	7.37
Wheat + G Gram + Pomace (60:25:15)	1.284	[illegible]	[illegible]	6.85
Wheat + G Gram + Pomace (60:20:20)	1.385	[illegible]	[illegible]	5.60
Ragi + G Gram (60:40)	0.804	[illegible]	[illegible]	9.80
Ragi + G Gram + Pomace (60:35:5)	0.857	[illegible]	[illegible]	9.63
Ragi + G Gram + Pomace (60:30:10)	1.094	[illegible]	[illegible]	9.53
Ragi + G Gram + Pomace (60:25:15)	1.182	[illegible]	[illegible]	9.00
Ragi + G Gram + Pomace (60:20:20)	1.138	[illegible]	[illegible]	8.85

G.Gram = Green Gram

and cashew apple pomace (residue) powder (0-20%) were blended and analysed for both physical and chemical properties (Table 4.7 and 4.8). Bulk density of different blends varied from 0.85 to 0.89. Water absorption capacity increased with increased concentration of cashew apple pomace powder in all the blends prepared. Cashew apple pomace has higher water absorption capacity (225.8%) compared to rice (109.3%), ragi (70.5%), wheat (54.6%) and green gram (68.8%). Consistency at 1:1.5 ratio increased with increased pomace concentration (pat spread decreased) indicating that higher concentration of pomace helps in retention of water by the flour blends.

Chemical composition of different blends is presented in Table 4.8. Composition of different flour blends with respect to protein, carbohydrate (starch), sugars was not influenced by inclusion of cashew apple pomace. Cashew apple pomace contains very low level of phytic acid, an anti nutritional factor (8.23 µg/100 mg) compared to ragi flour (15.1), green gram flour (310.99), whole wheat flour (18.04) and rice flour (19.85). Cashew apple pomace is rich in crude fibre (15.75%) compared to rice (0.03%), wheat (1.66%), ragi (3.04%) and green gram (0.28%). Crude fibre content in all the blends increased with increased concentration of cashew apple pomace powder. *In vitro* digestibility of protein and carbohydrate (starch) is not affected when cashew apple powder is blended upto 10% concentration. Cashew apple pomace carbohydrate could not be digested by incubation with diastase. It indicates that carbohydrate component in the pomace is indigestible. Cashew apple pomace could be blended with cereals and pulses upto 10% without affecting quality.

Table 4.8: Composition of different blends containing cashew apple pomace.

Blends	Proportion (%)	Protein (%)	Fat (%)	Sugars (%)	Phytic acid (µg/100 mg)	Crude fibre (%)	Tannin (µg/100 mg)	*In vitro* digestibility	
								Protein (%)	Carbohydrate*
Ragi flour	100	6.54	[illegible]	0.74	15.1	[illegible]	127.96	12.32	3.73
Green gram flour	100	40.23	[illegible]	5.09	310.99	[illegible]	34.43	35.12	3.36
Whole wheat flour	100	19.54	[illegible]	3.19	18.04	[illegible]	8.91	13.12	8.39
Rice flour	100	12.17	[illegible]	0.25	19.85	[illegible]	15.17	48.97	10.15
Cashew apple pomace powder	100	19.59	[illegible]	0.96	8.23	[illegible]	80.83	38.38	10.15
Rice + Green gram	60:40	22.65	[illegible]	2.43	160.43	[illegible]	14.23	52.93	10.31
Rice + Green gram + Pomace	60:35:5	23.95	[illegible]	2.08	116.43	[illegible]	15.42	46.97	10.74
Rice + Green gram + Pomace	60:30:10	20.89	[illegible]	2.08	113.34	[illegible]	19.72	69.90	10.31
Rice + Green gram + Pomace	60:25:15	22.51	[illegible]	1.40	39.89	[illegible]	20.23	23.07	8.04
Rice + Green gram + Pomace	60:20:20	20.39	[illegible]	1.30	35.49	[illegible]	20.79	7.76	7.49
Wheat + Green gram	60:40	25.36	[illegible]	3.43	105.53	[illegible]	15.49	41.36	7.64
Wheat + Green gram + Pomace	60:35:5	24.14	[illegible]	4.79	83.75	[illegible]	19.65	56.38	7.63
Wheat + Green gram + Pomace	60:30:10	17.38	[illegible]	2.43	93.45	[illegible]	18.58	47.09	3.69
Wheat + Green gram + Pomace	60:25:15	17.30	[illegible]	2.42	35.17	[illegible]	20.79	51.17	3.66
Wheat + Green gram + Pomace	60:20:20	24.28	[illegible]	4.89	26.29	[illegible]	22.63	88.62	5.81
Ragi + Green gram	60:40	19.81	[illegible]	2.11	107.77	[illegible]	57.74	37.12	4.73
Ragi + Green gram + Pomace	60:35:5	22.02	[illegible]	3.48	78.10	[illegible]	65.1	74.11	4.09
Ragi + Green gram + Pomace	60:30:10	17.38	[illegible]	2.43	93.45	[illegible]	66.85	40.9	3.69
Ragi + Green gram + Pomace	60:25:15	17.30	[illegible]	2.42	35.17	[illegible]	79.65	51.17	3.66
Ragi + Green gram + Pomace	60:20:20	16.30	[illegible]	2.11	55.14	[illegible]	91.82	43.18	3.30

Values are mean of three individual estimations.

* *In vitro* digestibility of carbohydrate is expressed as mg maltose released /3h/100mg flour blends

5. TRANSFER OF TECHNOLOGY

Establishment and monitoring of model ew clonal garden

In order to transfer the improved technologies ashew cultivation to the farming community h farmers participatory demonstration plots Central Sector Scheme of DCCD, Kochi, eight were laid out for high density planting in Kavu, r and Kanyana areas of Puttur taluk. High g lines such as Goa 11/6 and H 32/4 were ted for planting at a recommended spacing of m. With these, the number of demonstration tablished under this programme has risen to hile assessing the plots, factors such as removal t trees, gap filling, adoption of soil and water ation measures, adoption of initial training, ion of manures and fertilizers, staking and n of plant protection measures were considered. the assessment, the plots were categorized into verage and good based on the above criteria. e total 21 plots visited, 13 plots were rated as (61.90%) and remaining 8 plots were rated as (38.10%).

Demonstration farmers' meet

A meeting was organized on ICAR Foundation ain the newly selected demonstration farmers et the feedback from previous demonstration . The farmers were trained on various aspects ew cultivation regarding establishment, ment and plant protection measures. Farmers aken to field to demonstrate soil and water ation practices, high density planting system ntercropping in cashew. A total of 20 tration farmers participated.

Soil and water conservation and plant tion campaigns

Inrorder to create awareness among the cashew regarding the importance of terracing, opening pits and coconut husk burial as soil and water ation and plant protection measures against nd CSRB, four campaigns were conducted in gady taluk of Dakshina Kannada district in ation with Sri Kshethra Dharmasthala Rural opment Project, Dharmasthala. During campaign, odes of extension methods viz., exhibits such as panels, charts and live specimens wherever necessary, specially prepared literature, lecture-cum-discussion by subject matter specialists and field demonstrations were adopted. A total of 445 farmers participated in these campaigns. Pre-evaluation and post-evaluation were conducted to assess the effectiveness of the campaigns. After attending the campaign, the mean knowledge gained by the sample respondents was about 26% more than that of the knowledge already possessed by them.

5.4 Annual Cashew Day

Annual Cashew Day was organized on 14th March, 2002 to bring awareness among the cashew growers on the latest developments in cashew production technology and to get feed back on the effectiveness of the technologies transferred. A total of 120 farmers from Puttur, Sullia, Belthangady, Buntwal, Uppinangady and Udupi taluks representing twenty villages participated in the programme. They were taken to different experimental plots at Experimental Station, Shantigodu. Exhibition was also arranged for the benefit of farmers. Progressive farmers shared their experience regarding establishment of high density planting system, feasibility of organic farming in cashew and plant protection in the seminar organized during the Annual Cashew Day. This was followed by discussion in which farmers' doubts on various aspects of cashew cultivation were cleared. During the Cashew Day two technical bulletins viz., NRCC-Extension Bulletins (English and Kannada) on 'Questions and Answers on Cashew Production Technology' were released and distributed to the participants.

5.5 Impact of transfer of technology in cashew cultivation

A new project was initiated on 'Impact of Transfer of Technology in cashew cultivation". In order to collect the data about impact of cashew demonstration plots laid out at farmers field and impact of annual cashew day, 38 demonstration farmers and 29 farmers who attended the previous annual cashew days were interviewed.

5.5.1 Impact of demonstration plots

All the farmers adopted the planting technology

as recommended. Soil and water conservation measures were adopted by more than 80% of the demonstration farmers. More than half of them (55.26%) adopted initial training. Only about 20% of them applied fertilizers as recommended whereas, only two of them continued application of fertilizers even after withdrawal the subsidy. About 75% of them adopted plant protection measures against tea mosquito bug (TMB) whereas, only three of them adopted control measures against cashew stem and root borers (CSRB), even though 22 of them observed the symptoms of damage of CSRB (Table 5.1).

The impact was more for planting technology and soil and water conservation practices since these technologies were adopted during the period of subsidy.

The demonstration farmers did not follow the exa dose of recommended fertilizers. Since they gave lea importance for cashew compared to other plantatio crops they did not apply fertilizers after withdrawal subsidy. Since they did not realize the cause and effe of CSRB attack, they did not adopt control measure

5.5.2 Impact of Annual Cashew Day

About three-fifth of the farmers (58.62% adopted the recommended spacing and size of pits f planting cashew. About half of them (44.83%) us stakes for protecting young grafts from wind damag About one-fourth of them applied (24.14%) FYM the time of planting whereas, only 13.79% of the applied rock phosphate at the time of planting. Aroun

Table 5.1: Impact of demonstration plots and Annual Cashew Day

Recommended cashew cultivation practices	Demonstration Farmers (n = 38)				Farmers attended Cashew Day (n = 29)			
	Knowledge		Adoption		Knowledge		Adoption	
	No.	%	No.	%	No.	%	No.	%
I. Planting Technology								
a) Spacing								
b) Pit size								
c) Application of FYM / compost								
d) Application of rock phosphate								
e) Staking								
II. Soil and water conservation measures								
a) Contour bunding								
b) Trenching								
c) Application of organic mulch								
d) Avoidance of burning								
e) Application of FYM / compost								
f) Cultivation of cover crops								
III. Fertilizer application								
a) Quantity of fertilizers								
b) Time of application								
c) Method of application								
IV. Plant protection								
a) Identification of pests								
b) Knowledge about symptoms of damage								
c) Application of plant protection measures								
d) Knowledge about symptoms of CSRB attack								
e) Time of application of plant protection measures								
f) Adoption of plant protection measures								

thirds of them (65.52%) adopted terracing as, 44.83% of them opened catch pits. About rd of them (31.03%) adopted initial training. of them applied fertilizers as recommended s, about half of them (48.28%) had modified n of fertilizers. About one-third of them %) applied insecticides against TMB. Only one- of them (10.35%) adopted control measures t CSRB even though 44.83% of them had d symptoms of attack.

Adoption of soil and water conservation e like terracing and opening of catch pits was instead of recommended fertilizers, many of them farm yard manure or compost. Adoption of measures against TMB and CSRB was very less. the direct supervision of adoption of technologies e scientists was not there as in the case of stration farmers, the impact of cashew day s when compared to impact of demonstration

5.6 Technical advice provided by NRCC

An attempt was made to analyse the technical advice given by NRCC to various clients like cashew growers, government and private organizations related to cashew, NGOs and Cashew Manufacturers' Association. A total of 90 enquiries received between January, 2000 and December, 2001 were analysed. Out of the total enquiries nearly two-fifth (37.78%) was on transfer of technology viz., availability of planting material and literature on cashew. More than one-fifth of the enquiries (21.11%) was on crop improvement (varieties suitable for various cashew growing regions) and post-harvest technology. Nearly 10% of the enquiries were on crop management aspects (8.89%) and crop protection aspects (11.11%). Out of the total enquiries analysed, more enquiries were from farmers (48.90%) followed by government organisations (32.22%), private organizations (14.44%) and groups / associations (4.44%) (Table 5.2). Enquiries for technical advice were from eleven cashew growing states and two foreign countries (Nigeria and USA).

5.2: Clientwise classification of the enquiries.

	Farmer / Individuals	Groups / Associations	Private Organizations	Government Organizations
p Improvement	11	0	1	7
p Management	2	0	3	3
p Protection	1	1	0	8
st - Harvest Technology	7	0	7	5
ansfer of Technology	23	3	2	6
al	44 (48.90%)	4 (4.44%)	13 (14.44%)	29 (32.22%)

Address by Dr. EVV Bhaskara Rao, Director on ICAR Foundation Day

Plant protection/soil and water conservation campaign at Periyadka, Belthangady

Training on vegetative propagation of cashew

Farmers' seminar during Annual Cashew Day

Demonstration of softwood grafting technique during Annual Cashew Day

Demonstration of Japanese method of composting during Annual Cashew Day

6. STATISTICS

6.1 Development of yield forecasting model

In order to advise the processors well in advance regarding yield of cashew during ensuing year, a project has been initiated for developing yield forecasting model for cashew. Formula has been developed for estimation of cashew yield by using variables and constants such as estimated area under cashew for n^{th} year, incremental area for previous six years, 10 years moving average of productivity and 1st, 2nd and 3rd harvest area:

$$A_n = [(A_n - \sum_{i=1}^{6} A(n-i)\ ((\sum_{i=1}^{10} P(n-i)/10) + K) + (\sum_{i=4}^{6} A(n-i)^{*0.4})]$$

'A_n' is the estimated cashew area for the n^{th} year for which the yield estimate has to be worked out. This is calculated by taking average of growth rate for previous five years. The annual growth rate of cultivated area is calculated as follows.

Cultivated area growth rate = ({n^{th} year C.A* - $(n-1)^{th}$ year C.A) / (n-1)th year C.A)* C.A = cultivated area.

n^{th} year area estimate = ($(n-1)^{th}$ year cultivated area + ($(n-1)^{th}$ year cultivated area X Average growth rate of cultivated area over last 5 years))

As yield of cashew does not stabilize up to six years since planting, a factor incorporating the changes in incremental area is included in the formula to minimize the error. $\sum_{i=1}^{6} A(n-i)$ is sum of six years incremental area for previous six years which has to be subtracted from total estimated area for the n^{th} year.

$\sum_{i=1}^{10} P(n-i)/10$ is the moving average of productivity for the last 10 years. In order to get an accurate estimate of yield, n^{th} year productivity was calculated by deducting incremental area for previous three years from n^{th} year total cultivated area. The productivity of n^{th} year is calculated using the following formula.

(Production of n^{th} year / (total cultivated area of n^{th} year - previous three years incremental area))

A constant (K) is introduced to eliminate the unforeseen differences in yield due to pest and weather factors. For this purpose, constants like 0.15, 0.1, 0.075, 0.05 were tried to get the best fit. Area for the n^{th} year is calculated by deducting, incremental area for previous six years from total cultivated area of n^{th} year. Considering the fact that cashew gives minimal yield in 4th, 5th and 6th years (1st, 2nd and 3rd harvest). $\sum_{i=4}^{6} A(n-1)^{*}\ 0.4$ is introduced to nullify the error. Hence cultivated area of 4th, 5th and 6th years is multiplied by 0.4 MT. By using above formula bar graph is constructed for both actual and estimated yield for last one decade (Fig. 6.1).

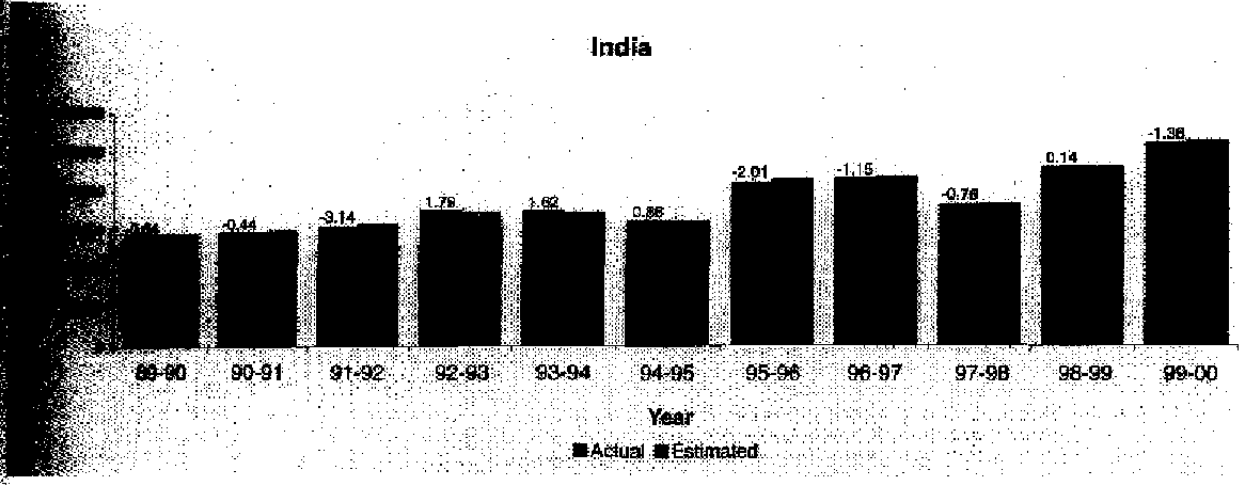


Fig. 6.1. Actual and estimated yield of cashew between 1989-90 and 1999-2000

the maximum variation in the negative side was observed in 1991 - 92 (-3.14). When the comparison of actual and estimated yield was done, state - wise, the maximum average error variation was observed for Karnataka state (-9.52 to 8.64) whereas, minimum error variation was observed for Andhra Pradesh (-0.96 to 1.49). For remaining states the variation ranged between -7.98 and -3.50 in the negative side and between 1.49 and 5.06 in the positive side (Table 6.3).

6.1.2 Yield forecasting for high density planti system

The variables such as age of trees, lig interception (%), ground coverage by canopy and yi were identified and the data was collected for differe densities viz., 156 trees/ha, 278 trees/ha and 625 tre ha. By using these variables regression equations we formulated for different densities and R^2 values we 0.85, 0.91 and 0.49 for 156, 278 and 625 trees/ respectively.

Table 6.3: State - wise average error variation

State	Error variation (%)
Kerala	-5.96 to 3.25
Karnataka	-9.52 to 8.64
Tamil Nadu	-3.50 to 5.06
Andhra Pradesh	-0.96 to 1.49
Maharashtra	-3.74 to 2.96
Orrisa	-6.62 to 1.55
Goa	-4.27 to 2.49
West Bengal	-7.98 to 2.14

7. CONCLUDED PROJECTS

Ad-hoc Scheme: Network programme on collection of cashew germplasm from east coast and west coast regions of India.

Principal Investigator	:	**MG Bhat**
Co-Principal Investigators	:	**KRM Swamy** **EVV Bhaskara Rao**
Research Associates	:	**Mr. Shruthakeerthiraja (1997-98)** **Mr. U. Vishu Kumar (1998-2000)** **Mr. CH. Yajnesh (1998-2001)** **Mr. D. Manjunath (2000-2001)**
Project Duration	:	**4 years (1997-2001)**

Introduction

Collection and conservation of gemrplasm are uisites for any crop improvement programme. d diverse types present in the crop species need lentified, collected and conserved before they . In view of the fast replacement of presently e local varieties / land races / elite types which eedling origin with the high yielding released s, the collection and conservation of germplasm receive top priority. Majority of the cashew tions raised by Cashew Development tion, Forest Development Corporation, cashew in east coast and west coast regions of India m chance seedlings. These trees of the ons have shown lot of variability.

Objectives

urveying the cashew plantations of seedling rigin in five states, namely, Tamil Nadu, Andhra radesh, Orissa, Kerala and Maharashtra for lentifying high yielding, elite and diverse types.

onservation of identified trees in the National ashew Gene Bank (NCGB) / Regional Cashew ene Banks (RCGBs).

Materials and methods

he scheme was implemented by NRCC, Puttur oration with six centres of AICRP on Cashew, Bapatla, Bhubaneswar, Madakkathara, Pilicode d centre), Vengurle and Vridhachalam.

ermplasm collection survey

he cashew germplasm collection surveys were undertaken during the fruiting season of each year from 1998 to 2001 covering all the five states. Important districts of each state known for the variability were included in the survey (Kerala - eight districts; Tamil Nadu - twelve districts; Andhra Pradesh - seven districts; Maharashtra - five districts and Orissa - six districts). While identifying trees for germplasm collection during the survey, ready reckoner of characterisation of core collections of National Cashew Gene Bank was also referred in order to avoid collection of the types which are already existing in NCGB. While conducting survey, characteristics of the trees including details of collection site were recorded. A total of 52 trees were identified during the survey.

B) Scion collection, production of clones and their conservation

During the grafting season of each year from 1998 to 2001, scions were collected from the trees identified (@50 numbers/tree) and half of the scion sticks from each tree was for NRCC and other half for the respective collaborating centres. The scions were grafted on root stock seedlings by adopting softwood grafting technique. The clones were maintained in the nurseries and field planted in the planting season of next year.

7.1.4 Results and Discussion

A total of 52 germplasm collections were made from Kerala (21), Tamil Nadu (7), Andhra Pradesh (4), Maharashtra (16) and Orissa (4). The salient features of the germplasm accessions collected are given in Table 7.1.

Table 7.1: Salient features of cashew germplasm collected from different states during 1998-2001.

S.No.	Collection Number	Name of collection	Salient Features
(I)	**Kerala**		
(a)	**Northern Region**		
1)	CG-3	Changaroth-3	Cluster bearing, High shelling %.
2)	IG-1	Iringal-1	Adapted to low nutrient status and low moisture condition. But low shelling %.
3)	MK-1	Makrari-1	Very long duration of flowering (Oct - April) and long fruiting period. High yield potential.
4)	PT-2	Pathiriyad-2	Bold nut (12.5 g)
5)	AR-3	Aralam-3	High yield per sq. metre of canopy. High proportion of flowering laterals.
6)	PNR-1	Panathur-1	High shelling (34.4%). High yield per sq. metre of canopy.
7)	PNR-2	Panathur-2	High yield per sq. metre of canopy. High yield and bold nut size.
8)	MLR-3	Muliyar-3	Bold nut size
9)	PRE-1	Periye-1	Compact and upright. Medium to bold nut size and big apple - Dual purpose type
(b)	**Southern region**		
10)	KR-1	Kainoor-1	Intensive branching. Medium nut size and big apple - Dual purpose type.
11)	PI-1	Peechi-1	Intensive branching. High yield/tree
12)	KTR-1	Kottarakkara-1	Very bold nut size (14.5 g nut weight)
13)	KTR-2	Kottarakkara-2	Very large apple size (120 g apple weight). High yield per sq. metre canopy.
14)	KTR-3	Kottarakkara-3	Two flowering periods (Dec-Jan and Apr-May) High shelling %. High yield
15)	KTR-4	Kottarakkara-4	CNSL-free type
16)	KTR-5	Kottarakkara-5	Both bold nut type (12.7 g nut weight) and high yield per sq. metre canopy.
17)	UNR-1	Ummannur-1	High shelling %, extended flowering period, High yield per sq. metre canopy.
18)	KK-1	Kottukkal-1	Bold nut size (13 g nut weight) and large apple size (120 g apple weight) compact.
19)	KK-2	Kottukkal-2	Intensive branching, very bold nuts (13.3 g nut weight)
20)	MR-1	Mannur-1	Bold nut size (12 g nut weight), juicy apples with apple weight of 85 g
21)	KJT-1	Kunjithai-1	Medium nut size
(II)	**Tamil Nadu**		
(a)	**Southern region**		
22)	KG-1	Kollangarai-1	High yield
23)	SL-1	Sekkalai-1	High yield
24)	PV-1	Puduvayal-1	Bold nut size

S.No.	Collection Number	Name of collection	Salient Features
25)	KX-1	Kanyakumari-1	High yield, Bold nut
26)	NK-1	Naduvakurachi-1	Compact plant type
(ii)	**Northern region**		
27)	VSK-1	Veerasingan Kuppam-1	High yield, High shelling %
28)	VSK-2	Veerasingan Kuppam-2	High yield, High shelling %
(iii)	**Andhra Pradesh**		
29)	PM-1	Petamalapalli-1	Compact plant type, high yield
30)	SC-1	Simhachalam-1	Compact plant type, Bold nut size High shelling percentage (32%)
31)	SC-2	Simhachalam-2	Compact plant type
32)	TP-1	Tummalapenta West-1	Compact plant type, cluster bearing, bold nut size
(iv)	**Maharashtra**		
(a)	**South Konkan region and Kolhapur district**		
33)	VS-1	Vengurle Samanth-1	Compact plant type. Flowers throughout the year. But weak flowering Nov - Jan. High shelling %
34)	VG-1	Vetore Gogate-1	Cluster bearing. High yield per unit sq. metre canopy
35)	KM-1	Kumbaramutt-1	Bold nut size, high yield
36)	PNS-1	Punas-1	Compact Plant habit, intensive branching , clean nuts
37)	WR-1	Wakawali Rukhi-1	High proportion of flowering laterals
38)	HB-1	Harukulu Budruku-1	High yield
39)	DZ-1	Ozram-1	High proportion of flowering laterals
40)	D-1	Devarde-1	Compact plant habit, intensive branching, high shelling %
41)	M-1	Masoli-1	Attachment of apple peduncle is tight
42)	AD-1	Arjunwadi-1	Comapct plant habit, intensive branching
43)	SB-1	Shenoli Budruku-1	Compact plant habit, intensive branching, high shelling %
44)	GB-1	Gangabhag-1	A freak type with normal size of tender nuts but with very small mature nut (nut weight 0.8 g).
(b)	**North Konkan region**		
45)	WG-1	Wangni-1	Compact plant type, big apple size (120 g apple weight)
46)	GS-1	Ghosale-1	Compact plant type, big apple size (120 g apple weight)
47)	AK-1	Amboli Karanjveera-1	High yield, intensive branching
48)	AK-2	Amboli Karanjveera-2	High yield compact plant type Intensive branching
(v)	**Orissa**		
49)	TG-1	Tapang-1	Compact plant habit, cluster bearing (25 nuts per panicle). High shelling %
50)	BK-1	Banjha Kusam-1	Cluster bearing (20 nuts per panicle). High shelling % (38%)
51)	RP-1	Ranasingpur-1	High shelling % (34 %)
52)	RP-2	Ranasingpur-2	Cluster bearing (20 nuts per panicle), High shelling %

A) Characterisation of accessions / trees

Most of the germplasm collections made from Kerala had high yield potential and also bold nut size and intensive branching habit. Kollam district contributed the largest number of diverse types. Kottarakkara-1 had very bold nut size with 14.5 g nut weight, Kottarakkara-4 is CNSL free type and Kottarakkara-5 had both bold nut size (12.7 g nut weight) and high yield (1.466 kg/sq. metre of canopy). Tamil Nadu collections had high yield potential and flowering duration of three months. Most of the Maharashtra collections had high yield. In another accession, namely Gangabhag-1 (GB-1) collected from Kolhapur district of Maharashtra, the size of tendernuts is normal while the mature cashewnuts are very small (nut weight of 0.8 g). It may be noted that nut weight of Gangabhag-1 is ten times lower than that of Ghosale-1. Most of the Andhra Pradesh collections were having upright and compact tree habit and all had short flowering season of 60 days duration. All the Orissa germplasm collections had cluster bearing with nut weight ranging from 4 to 5 g. Two collections each from Kerala and Maharashtra had bigger apple weighing 120 g.

B) Distribution pattern of gemrplasm collecti for different important characters

The different germplasm accessions collected from each state / region were grouped based on desirable / distinct characters. Among the five states, maximum number of desirable types were obtained from Kerala, followed by Maharashtra (Table 7.2). When the accessions of all the five states were considered together, 39 accessions out of 52 had high yield potential (> 500 g/m^2 canopy), 26 accessions had intensive branching, 25 accessions had cluster bearing habit and 22 accessions had bold nut size (> 9 g nut weight).

7.1.5 CONCLUSIONS

- A total of 52 accessions were collected from Kerala (21), Tamil Nadu (7), Andhra Pradesh (4), Maharashtra (16) and Orissa (4).
- One set of collected accessions was conserved at NCGB in NRCC, Puttur and another set was conserved in RCGBs of respective collaborating centres.
- Maximum number of desirable types was obtained from Kerala, followed by Maharashtra. Of the 52 accessions, 12 accessions had five or more desirable characters.

Table 7.2: Number of germplasm accessions collected from different states having desirable characters

State	Total collections made	Upright and compact tree habit	Intensive branching	Semi-tall growth (< 4 m)	Cluster bearing (> 6 fruits/ bunch)	Big sized apple (> 70 g)	Bold nut size (> 9 g)	Low apple to nut ratio (< 5)	High shelling percentage (> 30%)	Short duration of flowering (< 60 days)	High yield potential (> 500 g/m^2)
Kerala	21	3	13	2	11	9	14	2	5	3	15
Tamil Nadu	7	1	-	1	1	1	2	1	2	1	6
Andhra Pradesh	4	3	-	-	2	-	2	2	1	4	3
Maharashtra	16	9	12	2	7	3	4	3	4	3	10
Orissa	4	1	1	-	4	-	-	-	3	-	4
Total	**52**	**17**	**26**	**5**	**25**	**13**	**22**	**8**	**15**	**11**	**38**

7.2 Evaluation of elite germplasm accessions and recommended varieties of cashew under Project No. 1.2 - Varietal Improvement of Cashew

Project Leader : **MG Bhat**
Project Associates : **KRM Swamy and KV Nagaraja**
Project No. : **1.2**
Project duration : **Long-term (1986 - 2001)**

7.2.1 Introduction

Germplasm accessions can be used directly as varieties if found suitable on evaluation or be included as parents in the hybridisation programme. Large number of cashew varieties have been released in the country. A few of them are suitable for certain specific locations while some are suitable for wider areas.

7.2.2. Objectives

- Evaluating the performance of a few elite cashew germplasm accessions for yield and other economic characters and identification of high yielding with medium nut size types.
- Evaluation of the performance of a few recommended cashew varieties for yield and other economic characters.

7.2.3 Materials and methods

A) Elite germplasm accessions

Fourteen elite germplasm accessions / lines were evaluated in completely randomised design with 14 trees for each accession, each tree being considered as a replication. All the accessions were planted in the year 1988 at 8 m x 8 m spacing.

B) Recommended varieties

Trial-1

Ten recommended varieties were evaluated in RBD design with three replications. Plot size was six plants per variety per replication and the grafts were planted in1986 at 7.5 m x 7. 5 m spacing. VRI-2 was used as control for comparison of all the varieties within trial-1 and also between trial-1 and trial-2.

Trial-2

Nine recommended varieties were evaluated in RBD design with four replications. Plot size was six plants per variety per replication and the grafts were planted in 1991at 7.5 m x 7.5 m spacing. VRI-2 was used as control for comparison among the varieties within the trial-1 and between trial-1 and trial-2.

Varieties were evaluated for nut yield, nut weight, shelling %, flowering phases, hermaphrodite flowers %, sex ratio, status of adherence of testa and *in vitro* pollen germination using pollens from staminate and hermaphrodite flowers and biochemical parameters.

7.2.4 Results and Discussion

A) Evaluation of elite germplasm accessions

Among the 14 elite germplasm lines/accessions evaluated, seven genotypes were superior to check variety VRI-2 for cumulative yield for 11 annual harvests. The accession VTH 59/2 (13/5 Kodur) performed the best for cumulative yield (18.25 kg/tree) for 11 annual harvests which was closely followed by VTH 539/2 (M 76/2) (18.17 kg/tree) as compared to 15.67 kg/tree in VRI-2. The increase in cumulative yield of VTH 59/2 and VTH 539/2 over VRI-2 was 16.44% and 15.95% respectively. On the basis of pooled mean yield over 11 harvests also, highest yield was recorded in VTH 59/2 (13/5 Kodur) with pooled mean yield of 2.16 kg/tree/year followed by VTH 539/2 (M 76/2) with yield of 2.01 kg/tree/year as against the mean yield of 1.82 kg/tree year of VRI-2, the check variety (Table 7.3).

B) Evaluation of recommended varieties

Ten recommended varieties in first trial and nine varieties in second trial inclusive of VRI-2 as common check in each trial were evaluated. The performance of BPP-4 was found better than the remaining nine varieties in the first trial for the mean yield from 8th to 11th harvest (these 4 being better harvest seasons) with 2.25 kg nut yield per tree per year as compared to 2.13

Table 7.3: Pooled mean yield and cumulative yield in different elite germplasm accessions.

Genotype	Pooled mean yield (kg /tree / year) (11 harvest. Mean)	% difference in pooled mean yield over control	Cumulative yield (kg / tree) (for 11 harvests)	% difference in cumulative yield over control
VTH 13/2	1.73	-4.99	15.04	-4.03
VTH 30/4	1.62	-11.02	16.57	+5.73
VTH 40/1	1.71	-6.20	15.56	-1.96
VTH 155/2	1.91	+4.55	16.57	+5.70
VTH 92/2	1.63	-10.91	14.92	-4.82
VTH 102/3	1.56	-14.58	12.53	-20.06
VTH 574/2524	1.85	+1.21	15.98	+1.94
VTH 174/49	1.65	-9.59	15.06	-3.92
VTH 529/2 (M 76/2)	2.01	+10.42	18.17	+15.95
VTH 682/15	1.39	-23.79	12.14	-22.56
VTH 156/18	1.93	+5.54	16.42	+4.80
VTH 118/1	1.79	-1.97	16.53	+5.51
VTH 59/2 (13/5 Kodur)	2.16	+16.26	18.25	+16.44
VTH 194/12	2.00	+9.65	15.35	-2.02
M 44/3 (VTH 121) (VRI 2)	1.82	-	15.67	-
CD 5%	0.403		2.806	-
CD 1%	NS		3.704	-

Table 7.4: Pooled mean yield and flowering characters in different recommended varieties (Trial-1)

Variety	Pooled mean yield (kg/ tree/ year) (8-11 harvest Mean)	Pooled mean yield (Kg/tree / year) (13 harvest mean)	Cumulative yield (kg/ tree) for 13 harvest	Male flowering phase duration (days)	Mixed flowering phase duration (days)	% of Mixed flowering phase duration	% of Herma-phrodite flower	Sex ratio (herma-phrodite : stami-nate)
BPP-1 (H 2/11)	1.78	0.75	9.55	6.67	62.67	90.39	21.24	0.2697:1
BPP-2 (H 2/12)	1.95	0.94	12.17	30.83	41.67	57.48	12.24	0.1395:1
BPP-4 (EPM 9/8)	2.25	1.26	16.84	13.00	58.67	81.86	13.75	0.1595:1
BPP-5 (T.No.1)	2.07	1.16	15.04	12.83	63.00	83.08	17.75	0.2158:1
BPP-6 (T.No.56)	2.01	0.94	12.25	16.83	51.00	75.19	13.82	0.1604:1
BLA 139-1	1.63	0.83	11.53	8.83	66.17	88.23	18.72	0.2303:1
BLA 39-4	1.90	1.12	14.52	5.00	67.33	93.09	20.68	0.2607:1
Ullal-1	1.49	0.75	9.75	45.00	39.50	46.75	5.53	0.0585:1
VRI-1 (M 10/4)	1.48	0.90	11.73	14.50	60.50	80.67	15.42	0.1823:1
VRI-2 (M 44/3)	2.16	1.32	17.11	7.67	63.17	89.19	21.47	0.2734:1
CD 5%	-	0.3096	5.698					
CD 1%	-	0.4218	7.762					

ut yield per tree per year in VRI-2 (check variety) le 7.4). On the basis of pooled mean over 13 ests, VRI-2 performed better than the rest with kg per tree year per year which was followed by -4 with 1.26 kg per tree per year. When the ulative yield for 13 annual harvests was idered, the highest cumulative yield of 17.11 kg/ was recorded in VRI-2 which was followed by BPP- th 16.84 kg/tree. In the first trial, several individual ew trees have been identified with yield level of e than one ton per hectare in nine out of ten ased varieties.

In the second trial, the highest mean yield of 3 kg per tree per year from 3rd to 6th harvest was orded in K-22-1 as compared to 1.04 kg per tree per r in VRI-2 (check variety) (3rd to 6th harvests years ng better season for cashew). On the basis of pooled an over eight harvests, the highest mean yield of 4 kg/tree per year was recorded in NDR-2-1 as ainst 0.47 kg per tree per year of VRI-2 (check iety). When the cumulative yield was considered eight harvests, the highest yield of 5.95 kg per tree s recorded in NDR-2-1 as against 3.73 kg per tree of RI-2 (check) (Table 7.5). In this trial also, varieties such as K-22-1, BPP-3, Vengurla-4 had individual cashew trees with yield level of more than one ton per hectare.

Regarding the flowering phase and other flower characters, the data for six years (1995-96 to 2000-01) were pooled for male phase and mixed phase period, the proportion of mixed phase period to the total flowering phase period (%), proportion of hermaphrodite flowers to the total number of flowers (%) and sex ratio (hermaphrodite : staminate flowers) for all the 18 varieties from the two trials. Mixed flowering phase (> 5% hermaphrodite flowers) was observed in all the 18 varieties studied and in most of the varieties mixed flowering phase was of longer duration than that of male flowering phase (< 5% hermaphrodite flowers) with an exception of Ullal-1, and NDR-2-1 where mixed phase was of shorter duration as compared to male phase. BPP-1, and BLA-39-4 varieties had more than 90% mixed phase duration. Mean percentage of hermaphrodite flowers to the total number of flowers varied from 4.95% (NDR-2-1) to 21.47% (VRI-2). Range for sex ratio (herm:stam) was 0.0521 : 1 (NDR-2-1) to 0.2734 : 1 (VRI-2) (Table 7.4 and 7.5).

ble 7.5: Pooled mean yield and flowering characters in different recommended varieties (Trial-2)

Variety	Pooled mean yield (kg/ tree/ year) (3-6 harvests)	Pooled mean yield (kg/tree / year) (8 harvests mean)	Cumulative Yield (kg/ tree) for 8 harvests	Male flowering phase duration (days)	Mixed flowering phase duration (days)	% of Mixed flowering phase duration	% of Herma-phrodite flower	Sex ratio (herma-phrodite: stami-nate)
BPP-3	0.75	0.37	2.96	19.83	53.33	72.89	14.07	0.1637:1
K-22-1	1.33	0.53	4.24	38.33	41.83	52.18	5.98	0.0637:1
NDR-2-1	1.20	0.74	5.95	40.33	33.00	45.00	4.95	0.0521:1
Vengurla-1	1.03	0.55	4.36	21.83	46.00	67.82	11.45	0.1293:1
Vengurla-4	0.94	0.51	4.10	16.00	59.33	78.76	16.26	0.1942:1
Ullal-2	1.12	0.64	5.09	23.33	48.67	67.60	8.32	0.0907:1
NRCC Sel-1	0.76	0.33	2.62	20.00	63.33	76.00	11.98	0.1361:1
NRCC Sel-2	0.76	0.41	3.27	22.00	45.33	67.33	10.45	0.1167:1
VRI-2 (M 44/3)	1.04	0.47	3.73	16.83	56.83	77.14	13.83	0.1605:1
CD 5%	-	NS	NS					
CD 1%	-	NS	NS					

Longer period of mixed flowering phase is desirable wherein adequate number of staminate flowers which provide pollen having higher pollen germination and hence fertilization and also sufficient number of hermaphrodite flowers are available for better fruit set and finally higher nut yield. Certain varieties in first trial such as BPP-1, BLA-139-1, BLA 39-4 and VRI-2 exhibited both longer mixed phase (> 62 days) and also high percentage of hermaphrodite flowers (> 18% hermaphrodite flowers). However, the relationship between mixed flowering phase duration and high nut yield did not come true in three varieties having longer mixed phase and high hermaphrodite flowers %, namely, BPP-1, BLA 139-1 and BLA 39-4 although in VRI-2 it was found true. In second trial, although NDR-2-1 variety was having neither longer duration of mixed phase nor high % of hermaphrodite flowers, it was highest yielder on the basis of pooled mean and cumulative yield.

Correlation and regression analysis of flowering and fruiting characters with estimated nut yield and actual nut yield in eighteen recommended varieties was carried out for four years (1997-98 to 2000-01). The correlation and regression analysis done in each of the four years showed that number of flowering laterals per m^2 of canopy, fruiting intensity (number of nuts per m^2 of canopy) and yield per m^2 of canopy are important yield component characters in cashew. The correlation coefficient of number of flowering laterals with estimated yield per tree ranged from 0.433 to 0.618 in four years. The correlation of fruiting intensity and yield per m^2 of canopy with estimated yield per tree was found to be very strong in each of the four years and the range of correlation coefficients with estimated yield was 0.848 to 0.946 for fruiting intensity and 0.850 to 0.942 for yield per m^2 of canopy (Table 7.6). The regression coefficient of estimated yield per tree (Y) on number of flowering laterals (X) and fruiting intensity (X) was moderate which ranged from 0.110 to 0.409 and 0.316 to 0.469 kg/tree, respectively (Table 7.7). When analysis was done based on mean of three year data (1997-98 to 1999-2000) (2000-2001 excluded as number of trees used for observation was different during this year), the trend of correlation and regression between yield (estimated and actual) and flowering or fruiting characters has been the same as

Table 7.6: Correlation coefficient (r) of flowering and fruiting characters with estimated yield per tree (Y-1)

Characters (X)	Correlation coefficient (r)				
	1997-1998	1998-1999	1999-2000	2000-2001	3 year mean
Number of flowering laterals/m^2	0.433	0.618	0.494	0.470	0.515
Flowering lateral intensity (%)	0.446	0.291	0.186	0.057	0.246
Fruiting intensity (No. of nuts/m^2)	0.920	0.848	0.868	0.946	0.784
Yield per m^2 of canopy (g/m^2)	0.913	0.850	0.870	0.942	0.818
Actual yield (kg/tree)	0.549	0.131	0.180	0.423	0.189

Table 7.7: Regression coefficient (b) of estimated yield per tree (Y-1) on flowering and fruiting characters (X) - Independent variables.

Characters (X) Independent variables	Regression coefficient (b)				
	1997-1998	1998-1999	1999-2000	2000-2001	3 year mean
Number of flowering laterals/m^2	0.110	0.301	0.409	0.252	0.287
Flowering lateral intensity (%)	0.022	0.018	0.020	0.006	0.018
Fruiting intensity (No. of nuts/m^2)	0.316	0.377	0.469	0.449	0.360
Yield per m^2 of canopy (g/m^2)	0.056	0.058	0.075	0.082	0.060

that observed in individual four years (Tables 7.6 to 7.9). It may be noted that in all the individual years and group of years, the correlation and regression coefficients between actual yield per tree and flowering or fruiting characters were low (Table 7.8 and 7.9). The study indicated that fruiting intensity (number of nuts per m^2) and nut yield per m^2 of canopy can be used as important yield component characters for evaluating breeding material in order to select elite ones in a breeding programme for improvement of nut yield.

C) Status of adherence of testa to the kernel

Eighteen varieties of cashew were evaluated for four years (1998-2001) for status of adherence of testa to the kernel by recording the number of strokes of scrapping knife required for removal of testa. This character has special significance in cashew processing. The looser the attachment of the testa to the kernel, better it is in terms of savings on labour wages and also causing lesser damage to the kernel while removing the testa from the kernels, by using scrapping knife. The varieties were classified based on the number of strokes required to remove the testa completely into three categories, namely, loose (< 5.0 strokes), medium (5.0 - 7.5 strokes) and tight (> 7.5 strokes). Out of 18 varieties tested, NRCC Sel-1 had loose adherence. Fourteen varieties had medium adherence while the remaining three had tight adherence of testa. NRCC Sel-1 has been found to have consistently loose adherence of testa.

D) Pollen germination studies

In vitro germination using pollen grains from staminate and hermaphrodite flowers of 18 recommended varieties was studied by hanging drop method using cavity slides. Pollen grains were incubated in 25% sucrose liquid medium at 28°C ± 2°C for 20 h. Pollens from staminate and hermaphrodite flowers of 18 recommended varieties were studied during 1999-2000 and 2000-01. In the first year, pollen germination was studied at one stage of flowering while in second year it was studied at two stages. Hence the mean of two stages for each type of pollen source was calculated for the second year data. Varieties differed for *in vitro* pollen germination capacity. Pollen grains from staminate flowers had higher germination percentage as compared to those from hermaphrodite

Table 7.8: Correlation coefficient (r) of flowering and fruiting characters with actual yield per tree (Y-2)

Characters (X)	Correlation coefficient (r)				
	1997-1998	1998-1999	1999-2000	2000-2001	3 year mean
Number of flowering laterals/m^2	0.235	0.036	0.049	0.273	0.139
Flowering lateral intensity (%)	0.199	0.014	0.146	-0.006	0.036
Fruiting intensity (No. of nuts/m^2)	0.463	0.036	0.152	0.374	0.131
Yield per m^2 of canopy (g/m^2)	0.460	-0.026	0.122	0.314	0.077
Estimated yield (kg/tree)	0.549	0.131	0.180	0.425	0.189

Table 7.9: Regression coefficient (b) of estimated yield per tree (Y-2) on flowering and fruiting characters (X) - Independent variables.

Characters (X) Independent variables	Regression coefficient (b)				
	1997-1998	1998-1999	1999-2000	2000-2001	3 year mean
Number of flowering laterals/m^2	0.040	0.035	0.014	0.093	0.060
Flowering lateral intensity (%)	0.007	0.007	0.005	-0.000	0.002
Fruiting intensity (No. of nuts/m^2)	0.107	0.014	0.027	0.112	0.046
Yield per m^2 of canopy (g/m^2)	0.019	0.002	0.003	0.017	0.004

flowers in each of the varieties in both the years. The range of pollen germination was from 28.68% (VRI-2) to 46.27% (BPP-2) when staminate flowers were used as pollen source while the range was from 5.97 (NDR 2-1) to 15.96% (BLA-39-4) when hermaphrodite flowers were used as pollen source. The results of this study indicated that pollens from staminate flowers probably have more role to play in the fruit set through better pollen germination than those from hermaphrodite flowers. However, hermaphrodite flowers are also important as fruits and nuts are formed in those flowers. Therefore, longer period of mixed phase of flowering where both types of flowers exists would be desirable for better nut yield (Table 7.10).

Table 7.10 : Mean *in vitro* pollen germination (%) in two types of pollen source for 20 h in different recommended varieties for two year period (1999-2000 and 2000-2001).

Variety	Pollen source	
	Male flower	Hermaphrodite flower
BPP-1 (H 2/11)	41.80	11.77
BPP-2 (H 7/12)	46.27	13.94
BPP-3	38.06	10.24
BPP-4 (EPM 978)	40.06	7.68
BPP-5 (T.No.1)	42.29	9.77
BPP-6 (T.No.56)	38.74	11.12
BLA 139-1	34.03	15.56
BLA 39-4	33.91	15.96
NDR-2-1	28.93	5.97
K-22-1	32.79	6.83
Vengurla-1	36.45	9.58
Vengurla-6	36.25	7.13
VRI-1	42.34	14.23
VRI-2	28.68	13.01
NRCC Sel-1	32.93	6.54
NRCC Sel-2	35.36	14.78
Ullal-1	30.40	7.89
Ullal-2	45.86	8.40

E) Primegenic dominance studies

Primegenic dominance or dominance hierarchy is the phenomenon because of which first formed fruits reduced the chances of the fruit set from the later opened hermaphrindite flowers. Eighteen varieties were studied for primegenic dominance during 1998-99 and 1999-2000. Varieties differed for this phenomenon. However, the behaviour of varieties was not consistent in both years. In varieties BLA 139 1 and BPP 1 primegenic dominance was found operating in 1999-2000. In eight other varieties, namely, VRI-1, BLA 39-4, Ullal-2, VRI-2, K-22-1, BPP-3, NRC Sel-1 and V-4 the effect of primegenic dominance was less while in varieties BPP-2, BPP-5 and BPP-6 there was no primegenic dominance phenomenon in the early stages of flowering but it appeared in later stage in the year 1999-2000.

F) Biochemical characterisation and organoleptic evaluation of some cashew varieties

Cashew kernels, apple juice and apple pomace from the 18 recommended varieties have been characterised for biochemical composition and salient findings are given below:

a) Cashew kernels

Cashew kernels from 17 recommended varieties were characterised for oil, protein, sugar and starch contents. Further, they have been organoleptically evaluated for colour, size, texture and taste by a panel of judges, using a 9-point hedonic scale. The oil content among the varieties studied varied from 34.7 (NDR 2-1) to 48.4% (Kanaka). Proteins, sugars and starch content were analysed on defatted flour. Kernel protein content varied from 35.60% (NDR-2-1) to 65.82% (BPP-6). Sugar content showed variation between 6.98% (VRI-1) to 20.62% (V-6). Starch content among different varieties varied from 17.50% (BPP-6) to 25.70% (V-1). Among the varieties evaluated for sensory characters, NRCC Sel-1 was the most preferred with mean cumulative hedonic (MCH) score of 7.1 while BPP-3 and BLA-139-1 were least preferred with MCH score of 18.7 (Table 7.11).

b) Cashew apple juice

Clarified cashew apple juice from apples of 16 recommended varieties was prepared by

able 7.11: Comparison of varieties for kernel composition and sensory acceptability.

Variety	%				Mean Cum. Hedonic Score	Kernel grade
	Oil	Starch	Sugars	Protein		
BPP-1	45.4	19.4	9.25	60.77	11.5	W-400
BPP-2	47.4	18.84	16.19	52.77	15.6	W-450
BPP-3	42.9	19.6	8.86	53.77	18.7	W-400
BPP-4	39.6	19.9	8.86	59.83	11.2	W-400
BPP-5	47.1	22.9	10.90	53.32	12.1	W-400
BPP-6	43.5	17.5	9.40	65.82	12.8	W-400
BPP-8	43.3	18.1	10.67	54.76	12.4	W-210
Bhubaneswar-1	43.6	21.5	11.08	51.84	14.7	W-320
Chintamani-1	46.7	18.29	9.84	57.36	9.8	W-210
Jhargram-1	42.5	14.5	10.18	62.97	12.0	W-320
BLA 139-1	35.3	18.9	9.56	52.3	18.7	W-280
BLA 39-4	43.0	23.5	13.05	54.56	11.6	W-280
NDR-2-1	34.7	28.3	8.08	35.6	12.0	W-240
K-22-1	42.2	19.0	11.14	53.21	12.1	W-280
Dhana	47.1	16.4	15.57	52.05	11.1	W-210
Kanaka	48.4	19.79	14.59	49.15	14.5	W-210
Priyanka	47.6	21.29	15.54	53.60	10.8	W-180
Amrutha	44.9	19.78	10.43	53.96	13.2	W-210
V-1	37.9	25.7	7.3	46.0	15.5	W-240
V-2	47.5	22.44	15.28	57.37	10.8	W-320
V-3	42.9	24.69	15.58	58.69	12.6	W-210
V-4	38.2	19.8	7.31	52.8	12.8	W-210
V-5	43.9	21.81	14.55	52.47	7.9	W-400
V-6	42.8	25.18	20.62	48.77	10.9	W-210
V-7	44.6	20.11	14.51	55.69	11.9	W-180
VRI-1	39.7	19.7	6.98	53.5	11.1	W-320
VRI-2	36.8	21.5	8.15	51.3	13.2	W-320
VRI-3	41.9	15.9	10.80	61.36	8.8	W-210
Sel-1	37.2	20.1	8.3	48.4	7.1	W-210
Sel-2	37.3	21.9	7.73	51.3	10.5	W-210
Ullai-1	38.5	21.4	7.77	47.6	9.1	W-210
Goa -1	42.7	17.7	10.26	54.38	12.2	W-210

Values for oil, starch, sugars and proteins are mean of three individual estimations. MCH indicates the mean cumulative hedonic score for colour, size, texture and taste of 15 judges.

boiling the cashew apple juice with gelatin (500 mg/l) and allowed to stand for 15 min and the clear supernatant obtained after 24 h at 10-16°C was analysed for biochemical composition such as tannins, flavonols, sugars and ascorbic acid and organoleptic acceptability for colour, flavour, taste and astringency by a panel of judges using a 9-point hedonic scale. Tannin content varied from 0.62 (VRI-2) to 7.96 mg/ml (BPP-5).

Table 7.12: Biochemical composition of cashew apple juice of released varieties (mg/ml).

Variety	Tannins	Flavonols	Sugars	Ascorbic acid	MCH score
BPP-1	0.810	0.024	36.07	2.52	15.40
BPP-3	7.498	0.519	11.80	2.93	18.21
BPP-4	2.682	0.335	73.7	2.31	15.00
BPP-5	7.960	0.647	38.14	2.76	21.11
BPP 6	4.111	0.096	44.76	5.10	17.19
BLA 139-1	2.602	0.207	6.56	4.75	15.47
BLA 39-4	2.813	0.523	81.81	1.25	19.00
NDR-2-1	1.515	0.030	25.25	4.11	19.28
K-22-1	1.77	0.087	23.29	2.69	15.5
V-1	3.364	0.096	25.44	5.11	16.38
V-4	6.081	0.138	40.11	3.63	17.52
VRI-1	4.680	0.297	30.22	4.08	14.89
VRI-2	0.622	0.058	55.30	1.76	18.10
NRCC Sel-1	2.469	0.192	11.00	3.09	14.0
NRCC Sel-2	7.111	0.352	14.11	4.15	18.60
Ullal-2	4.040	0.172	16.45	4.18	16.0

Values for tannins, flavanols, sugars and ascorbic acid is mean of three individual estimations. MCH values are mean of 15 judges.

Table 7.13: Composition of cashew apple pomace (mg/100mg).

Variety	Protein	Carbohydrate	Sugar	Tannin	Fibre
BPP-1	20.97	35.86	0.262	0.163	14.36
BPP-3	21.36	44.63	0.350	0.135	16.39
BPP-4	22.99	36.47	1.392	0.115	13.23
BPP-5	24.69	26.79	1.393	0.276	14.36
BPP-6	18.39	36.28	0.469	0.161	18.21
BLA 139-1	31.11	47.40	0.664	0.125	14.03
BLA 39-4	18.73	42.00	1.256	0.224	14.41
NDR 2-1	28.94	46.47	0.395	0.073	15.59
K-22-1	28.01	45.92	0.464	0.115	14.10
V-1	21.26	35.38	0.315	0.132	18.30
V-4	21.29	47.41	0.732	0.084	11.64
VRI-1	20.20	45.69	0.165	0.101	14.57
VRI-2	24.65	38.85	0.445	0.117	15.31
NRCC Sel-1	30.65	46.54	0.479	0.083	15.85
NRCC Sel-2	19.96	43.26	0.430	0.172	17.17
Ullal-2	21.34	35.89	0.292	0.081	13.27

Values are mean of three individual estimations

Similarly, flavonols content varied from 0.024 (BPP-1) to 0.647 mg/ml (BPP-5). Sugar content showed variation between 6.56 (BLA-139-1) and 81.8 mg/ml (BLA-39-4). Ascorbic acid varied from 1.25 (BLA-39-4) to 5.11 mg/ml (V-1). Mean cumulative hedonic score for colour, flavour, taste, and astringency varied from 14.0 (Sel-1) to 21.11 (BPP-5). Among the varieties, cashew apple juice from five varieties had low tannin (1 to 3 mg/ml), 11 varieties had high ascorbic acid content (2 to 5 mg/ml), seven varieties exhibited MCH score ranging between 13 and 17 (Table 7.12).

) Cashew apple pomace

Pomace obtained after squeezing out juice from apples of 16 different released varieties was anlyased for fibre, protein, carbohydrate, sugars and tannin. Cashew apple pomace is quite rich in fibre and it varied from 11.64% (V-4) to 18.3% (V-1) and low in tannin. Pomace is quite rich in protein and carbohydrate also (Table 7.13).

7.2.5 CONCLUSIONS

- The germplasm accessions differed for yield and yield component chracters. VTH 59/2 (13/5 Kodur) and VTH 539/2 (M 76/2) identified from this trial on evaluation of 14 germplasm accessions are recommended for utilizing in the crossing programme.
- Large variation was observed among the 18 recommended varieties for most of the economic and other chractesrs evaluated in two trials. Several individual cashew trees have been found with yield level of more than one ton per hectare in most of the varieties evaluated. Mixed flowering phase for longer duration may be desirable for achieving higher yield.
- Cashew kernels from some of the released varities have been analysed for oil, proteins, starch, sugars and organoleptic acceptability. Similarly some of the released varities have been analysed for cashew apple tannins, flavonols, sugars, ascorbic acid and organoleptic acceptability. Cashew apple pomace of some of the released varities have been analysed for proteins, carbohydrate, sugars, tannins and fibre.

7.3: Developing database on processing aspects of cashew industries in India

Project Leader	:	**D. Balasubramanian**
Project No.	:	**4.2**
Project duration	:	**3 years (1995-1998)**

7.3.1 Introduction

The main purpose of this study was to outline the operational conditions of cashew processing industries in different parts of the country, the problems faced and to examine the prospects of the cashew industry development in India. The detailed study of these processing units would help in unravelling the problems for low production of these industries and finding out solutions for them.

7.3.2. Objectives

- Studying the prevailing processing practice, system of storage, plant and personnel hygiene of cashew processing industries of different regions and refining the technique of processing for efficient outturn.
- Studying the employment potential, production, and equipment needs of these industries to forecast the impact of mechanisation in these regions.
- Working out the processing cost in cashew nut processing at various stages of operation.

7.3.3 Materials and methods

The list of cashew processing industries' addresses in different states was prepared after collecting information from Cashew Export Promotion Council, Kochi and Directorate of Cashew and Cocoa Development, Kochi.

Technical questionnaire Part-I and Part-II were prepared for collecting information on cashew processing industries. The Part-I questionnaire was meant for manager or administrator of processing industries and consisted of 17 questions regarding ownership pattern, location of the factory, category of processing, procurement of raw nuts including source, quantity and method, and employees information in terms of strength, wages and facilities provided.

Part-II was a technical questionnaire meant for supervisor of the cashew processing industries consisting of 54 questions on storage of raw cashew nuts, drying of nuts, conditioning/preliminary roasting, cooling, shelling, kernel drying (Borma), peeling, grading and packing and CNSL extraction. The Part-I and II questionnaires were pre-tested by personal visit to cashew processing industries. The modified questionnaire was mailed to all the cashew processing industries in India. Due to poor response and for early completion field survey was also conducted. The data collected on management and processing aspects were analysed for Kerala, Karnataka and Andhra Pradesh states. An overall analysis on critical areas is also attempted.

7.3.4 Results and Discussion

A) Cashew processing industries in Kerala

Cashew processing industries in Kerala are mostly concentrated in Quilon area only. Besides Quilon, the processing industries are operating in Trivandrum, Allepy, Pathanamthitta and Thrissur districts (Table 7.14). As a result of differences in organisations of labour, legislation and wage rates many factories have been shifted to Kanyakumari district of Tamil Nadu state. Only 25% of the total industries have the capacity to run the factory throughout the year and their utilised capacity falls

Table 7.14: Details of Cashew processing industries in Kerala

Number of cashew factories in the state (registered)	:	406
Installed capacity of cashew factories	:	5941 MT/day
Utilised capacity	:	4066 MT/day
Total number of cashew workers	:	2,22,817
Total quantity of raw cashew nut required to provide full employment to the cashew workers	:	1,78,230 MT

er the category of 1000-5000 MT/annum. ernment of Kerala fixes the wages to labourers king in various sections of industries and 8.33% us is given to motivate the workers.

Immediately after procurement, raw nuts are sun dried for 2-3 days depending on the moisture content of nuts. Imported nuts do not require drying as it loses its moisture during transportation.

Most of the processors follow drum roasting as preliminary process. About 4% of total units visited have switched over to steam boiling and oil bath roasting (11%) is continued due to financial crisis to install new units.

Drum roasting consists of feeding tank constructed at raised level so as to move the raw nuts to rotating drum by gravitational force. A normal slope of 4° is given from inlet to outlet of drum. Water sprinkled at the outlet prevents nuts from catching fire. Feed rate and rotational speed of the drum are important factors, which decide the quality of kernels after roasting.

In drum roasting type, the nuts are hit with mallet (wooden block) to break open. About 92-95% of wholes are recovered in this method and the effect of CNSL on the hands of workers is less.

In conventional type borma dryer, utmost care is taken by regularly shifting the kernel trays and controlling the fire beneath hot chamber to avoid scorching of kernels. In tunnel borma, blowers (electrically operated) are used to pass hot air into drying chamber through tunnels wherein the flow rate and temperature of hot air are controlled.

The wholes recovery after peeling ranged between 80-90% in peeling section. An average of 8-12 kg cashew kernels are peeled/head/day. Two industries have very recently introduced flexible packaging system in which N_2 is used as inert gas.

High degree of hygienic condition is maintained and Potassium permanganate solution is used to wash the hands and legs of the labourers before starting peeling and grading to avoid contamination.

B) Cashew processing industries in Karnataka state (Dakshina Kannada)

The area of the study covered erstwhile Dakshina Kannada district, where predominantly all the cashew processing industries of Karnataka are located. The industries are concentrated in urban and semi-urban pockets. Most of the industries have road link with the main city. The need for electricity in this industrial sector is high but the supply of power is inadequate and erratic.

In order to ensure fair representation, most of the units under Mangalore Cashew Processors' Association (MCPA) have been identified for intensive investigation. MCPA is responsible to run the units in a co-ordinated and planned way (Table 7.15).

Table 7.15: Cashew industries under MCPA (1998)

Taluks	No of units
Kundapura	18
Karkala	33
Udupi	08
Mangalore	20
Bantwal	02
Sullia	02
Puttur	04
Others	07
Total	94

- Out of the total 94 industries surveyed, only 59 units with complete information are taken for analysis. Most of the units have been started in eighties due to highest value for Indian Cashew Kernels in the international market in late seventies.
- Processing industries have simple organisational structure and 83% of the industries come under the category of partnership. About 70% of the firms suffer due to inadequate supply of raw nuts for functioning throughout the year.
- Fifty seven per cent of the industries' raw nut purchasing capacity is in the range of 101-500

MT per annum and visual, floating and cutting test are practised at the time of procurement.

- All factories followed steam boiling as preliminary conditioning method, but the production capacity differed. There is wide variation in steam treatment especially steam pressure and duration.
- Shelling is done using hand cum pedal operated sheller and the average capacity ranged from 11-30 kg kernels/pair/day. Varying size of nuts require careful manipulation during cutting to avoid injury to hands.
- The heat utilisation of cross flow dryer is higher than conventional type and it has the advantages of uniform kernel drying and lesser time. Processors are unable to switch over to cross flow drier from poorly designed borma drier due to erratic power supply.
- Peeling is done manually using pellets and capacity of labours varied from 4-12 kg/day. About 4-7 preliminary grades are segregated after peeling.
- About 45 grades are sorted for local consumption and export. Kernels are packed in tin containers of 25 lbs (11.54 kg) capacity by vita packing system . Processors are gradually switching over to flexible packaging system.
- Expeller is used to extract CNSL from cashew shell and about 200 ml of CNSL/kg is extracted. CNSL, thus extracted is mostly exported.

C) Cashew processing industries in Andhra Pradesh

Cashew processing industries in Andhra Pradesh are located in Rajahmundry (4), Vetapalam (27), Palasa (68), Tuni (12), Haripuram (6), Kanchilli (4), Chappra (3), Pathetakkali and Tekkali (3) and Srikakulam (2). The first unit of cashew industry was started in 18th century in Mori of Rajahmundry. Gradually units emerged in Vetapalam and Palasa in the beginning of 19th century. In Palasa cashew processing industry started in 1944 with three units only grew to 12 industries in 1954. At present, a total of 68 processing units are there in Palasa and Kasibugga area. Almost all the units are categorised under tiny units based on its power requirement and total capital involved. The estimated processing capacity of all these units is 20,000 t/annum and generated employment for 3000 persons. Only 22% of total units function throughout the year due to less demand of cashew kernels in local market, insufficient financial support and loan facility from banks

- Palasa cashew exporters private limited exports cashew kernels worth Rs. 30-35 lakhs from this region every year.
- Very recently, this region has been declared as pollution affected area and promotion of industries in this place is not encouraged. Instead, government has announced 20% subsidy for infrastructure to set up processing industry in industrial area.
- Most of the cashew processing industries functioning (factory and management units) at Palasa and Kasibugga area followed drum roasting. Shelling and peeling are done manually to extract the kernel. The kernel is sold in domestic market only.

D) Cashew processing industries in India [Overall analysis]

India is the largest producer of raw cashew nut in the world and accounts for 43.8% of the total world production (1998). This raw material wealth is a positive aspect for promoting processing industry. At present over 1295 cashew industries are functioning in different states of India (Table 7.16). Based on the information furnished by 132 industries (12.42%), the critical area are analysed and the results summarised.

- Cashew industries have a simple organisational structure and mostly under private management i.e., proprietorship (63%) or partnership (19%). Since it requires large amount of initial investment and running capital, it depends on commercial banks and state financial agencies for running capital.
- About 62% of the industries are categorised under "manufacturer exporter". This is primarily due to encouraging export policy.

Table 7.16: **Cashew processing industries in India**

State	1995	1998	2001
Andhra Pradesh	46	189	189
Karnataka	78	94	160
Kerala	271	420	421
Goa	43	44	44
Maharashtra	28	29	29
Orissa	20	20	89
Tamil Nadu	209	234	324
West Bengal	39	32	32
Others (Manipur, Meghalaya, Tripura)		09	07
Total	734	1071	1295

- During off-season, in order to run the factory throughout the year, 50% of the total factories import raw nut. Inadequate supply of raw nuts and fluctuating price make the processors heavily depend on the raw nut import from West and East Africa, Ivory Coast, and Vietnam.
- Tiny processing units (up to 100MT/year) and medium capacity processing industries (100-500MT/year) account to 39% and 42% respectively. This is mainly due to raw nut shortage and financial constraint. Most of the industries utilised capacity is below 50%.
- Total employees strength varied between 50 and 400. About 80% of the total women employees are involved in shelling and peeling. The wages fixed by the government at different stages of operation are followed strictly.
- Drum roasting (66%) as preliminary roasting is followed in Kerala, Tamil Nadu, Andhra Pradesh, Orissa and West Bengal. The latest method of steam boiling (27%) is practised in Karnataka, Goa and Maharashtra. Very few industries (7%) are still following outdated method of oil bath roasting.
- Raw nuts feed rate and rotational speed of drum are the two important factors which decide the quality of processed kernels. Duration of boiling and steam pressure have main bearing on the kernel quality in steam boiling.
- Drum roasted nuts are shelled by mallet/stone hit and steam boiled nuts are decorticated by hand cum pedal operated cutting unit. Though the workers apply ash on nuts in drum roasted nuts and castor oil on hand in the case of steam boiled nuts, their hands are prone to the adverse effect of CNSL. In few factories, labourers in shelling section are provided with hand gloves to avoid contact with the CNSL.
- Steam boiled nuts are cooled for 10-20 h to make shells brittle and to make cutting operation easy. Besides, this operation enhances the wholes recovery also. However, the cooling of drum roasted kernels is done for 1-2 h to allow the CNSL to drain out and to reduce the temperature of nut.
- Three different types of kernel dryers are being used
  - Conventional eight feet borma dryer, constructed with brick and mud. The kernels are spread on wire mesh tray and subjected to hot air by placing in a chamber above furnace. It requires highly skilled labour to control temperature to avoid scorching of kernels.
  - Tunnel dryer in which hot air produced outside is passed into the drying chamber through tunnels. Heat utilisation efficiency

is higher, but it requires constant attention to get better quality kernels.

- Electrical borma dryer, in which both temperature and flow rate of hot air are automatically controlled by thermostatic mechanism. It requires only 4 h to dry 400kg of kernels. It consisted of 120 trays in 4 trolleys with 4 kg holding capacity. Kernels are dried at 70°C. The main advantage of this system is uniform drying and minimum supervision.

- Peeling is a labour intensive process. Normally, testa is removed using fingernails. Many industries in Karnataka, Goa, Maharashtra, Orissa and West Bengal use pellets (mild steel knife) to remove the testa. Wages are fixed on the basis of whole kernels and this serves as a control for careful work.

- Humidification of kernels is one of the processes followed during summer to avoid excessive breakage while handling and transport. The permissible moisture content after packaging is 5%.

- The graded kernels are packed in 25 lbs (11.34kg) capacity tins on weight basis which are subsequently evacuated and filled with CO_2 with the help of packing unit called "vita pack" to prevent spoilage due to rancidity.

- Since the kernel importing countries imposed restrictions on tin containers due to the problem of disposal, flexible packaging with N_2 gas infusion is introduced in India. About 8% of processors have switched over to new packaging system.

- Oil expeller (15 HP) is used for CNSL extraction. Oil after extraction is transferred to boiling unit and heated at 100°C for 4 h to remove moisture. The heated oil is cooled for 10-12 h in settling tanks. It is estimated that 20 kg of crude oil can be extracted from 100 kg shell and sold at the rate of Rs. 20/kg refined oil.

- Processing cost of oil bath roasting, drum roasting and steam boiling is worked out and compared (Table 7.17). Processing cost of steam boiling is slightly higher than drum roasting, but it has added advantage of CNSL being recovered.

Table 7.17: Comparison of processing cost by different methods (Rs/kg)

Processing stages	Oil bath roasting (Calicut)	Drum roasting (Palasa)	Steam boiling (Mangalore)
1. Drying raw nuts	0.13	0.06	0.15
2. Preliminary roasting			
i) Labour wages	0.12	0.09	0.18
ii) Fuel charges	0.25	0.03	
3. Shelling roasted nuts	1.89	0.93	1.28
4. Kernel drying (Thermal dried)			
i) Labour wages	0.20	0.02	0.19
ii) Fuel charges	0.10	0.04	
5. Peeling	1.30	0.82	1.26
6. Grading	0.24	0.10	0.57
7. Packaging			
i) Wages			
ii) Consumables & Soldering	1.54	1.08	1.53
iii) Infusion of CO_2	5.27	3.12	5.16
Advantage	Extraction of CNSL, but discoloured oil		Extraction of CNSL of superior quality and refine oil shell cake

Problems identified and probable remedial measures suggested

1) Procuring quality raw nut

At present raw nuts are procured mostly based on personal experience. Floating or cutting test forms the criteria to fix the price. Moisture content of raw nut has strong bearing on quality of final product and fixing the price. Therefore, raw nut moisture content along with prescribed quality standards have to be developed.

2) Increasing the shelf life of raw cashew nuts

The storage life of raw nuts in the godown depends on the quality of nuts and its storage conditions. Fluctuating temperature is deleterious during storage due to condensation of moisture in the godowns at certain pockets and consequent microbial growth. Therefore equilibrium moisture content of raw nuts has to be determined. In order to dry nuts during rainy season electrical drier needs to be developed.

3) Increasing white kernels recovery

In the case of steam boiling, pressure and duration have to be optimised for nuts of various origin with respect to capacity of the unit. The critical speed (rpm) of drum and optimal feed rate have to be determined for drum roasting.

4) Drudgery of labourers in shelling process

In order to minimise the drudgery of labourers operating shelling unit and to avoid effect of CNSL on the hands of the operator, improved cutting unit for steam boiled nuts and impact unit for drum roasted nuts are to be developed.

5) Scorching of kernels in borma drier

Maintaining uniform circulation of hot air at constant temperature throughout drying process in tunnel drier by providing thermostatic control could minimise scorching of kernels. Electrical borma drier may be used for medium capacity.

6) Maximising whole kernel recovery in peeling process

Mechanical means to peel the testa automatically by puncturing the testa layer and peeling through forced air may be tried.

7) Alternate packing system

Either flexible packaging system with N_2 gas infusion or moulded vacuum packaging may be followed which will reduce the packaging cost to a greater extent.

7.3.5 Conclusions

- The increasing demand for kernels in the international market and the availability of cheap labour (women) possessing the required skills in processing are the two important favourable factors for the rapid growth of cashew processing industry in India.
- The quantity of raw nuts available for processing has, however, fallen short of the requirements for full use of the capacity. The shortage of raw nuts has resulted in curtailment of the days of employment for the large number of workers dependent on cashew processing.
- Oil bath roasting which has additional advantage of obtaining the cashew nut shell liquid (CNSL) is adopted by only a few processors, presumably because of the capital investment required for the adoption of technology which is ten times more than the drum roasting as investments. Moreover the unpurified CNSL does not attract sufficiently wide market. Therefore, creation of additional capacity in the industry and emergence of new industry has to be discouraged.
- Cleanliness in processing units has to be given utmost importance. Authorities issuing license for cashew processing industries has to be very critical in this direction.
- Optimisation of every processing step has become urgent. The principal requirements for the development of mechanised cashew processing plants will be the efficiency in the production of unscorched kernels and maximum recovery of CNSL. Highly mechanised plant will create social problems because the existing plants are highly labour intensive. Therefore, simple mechanisation without creating social upheaval to increase the whole nut yield has to be tried.

7.4: Design, development and evaluation of raw cashew nut grader

Project Leader	:	**D. Balasubramanian**
Project No.	:	**4.3**
Project Duration	:	**3 years (1995-1998)**

7.4.1 Introduction

Cashew industry is of considerable importance to the Indian economy as a source of foreign exchange, employment generation and farmer's income. Over 1200 processing units situated in east and west coast of India have the installed capacity to process more than 10 lakh MT of raw cashew nut. Raw cashew nut is kidney shaped one with 3.5mm thick soft leathery outer skin (epicarp) and thin hard inner skin (endocarp). Between these two walls of the shell is a honeycomb structure, which contains the phenolic material, commercially, known as cashew nut shell liquid (CNSL). Preliminary grading of raw nuts helps to condition the nuts uniformly, reduces manipulation of nuts according to nut sizes while shelling, reduces the burden in peeling and grading stage and forms criteria to fix up the price.

7.4.2 Objectives

This project is formulated with an objective of developing and evaluating power operated raw cashew nut grader.

7.4.3 Materials and methods

A) Properties of raw cashew nut

As the raw nut is kidney shaped and its curvature of sides varies with size of the nut, physical parameters of raw cashew nuts namely length, width, thickness, specific gravity, and shell thickness and mechanical properties such as static co-efficient of friction and angle of repose are found out.

Raw cashew nuts obtained from Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra, Orissa, Goa and West Bengal (moisture range 4.5 - 10.5% db) are used in the experiments. The initial moisture content of the sample was determined by toluene distillation method. The desired moisture content was obtained by drying at 40°C to give a sample mass as calculated below:

$$B = A\,(100-a)/(100-b)$$

The samples of higher moisture contents were obtained by adding distilled water as calculated from the following relation.

$$Q = A\,(b-a)/(100-b)$$

Where

A - Initial mass of the sample, kg

B - Final mass of the sample after drying, kg

a - Initial moisture content of sample, % wb

b - Final (desired) moisture content of sample, % wb

Q - Mass of water to be added, kg

Finally the moisture content of raw nut samples were expressed in % db using the equation

$$Md = (Mw \times 100)/(100-Mw)$$

Where

Md - Moisture content % db ; Mw - Moisture content % wb

B) Dimensions of nuts and kernels

In order to determine the size and shape of the nut, three sub-samples, each weighing 1.5kg were randomly drawn from the bulk sample. From each of three 1.5kg sub-samples, 200 nuts were picked and 600 nuts thus obtained were mixed thoroughly. Finally, 200 seeds were randomly selected and labelled. For each individual nut and corresponding kernel, length, width and thickness were measured using electronic micrometer. Because of irregular shape of cashew nut and kernel, only the greatest values of both width and thickness have been taken. The equivalent diameter (De) and sphericity ⊗ for both nut and kernel were determined using the following expressions.

$$De = (LWT)1/3$$

$$\otimes = (LWT)1/3/L$$

Where L, B, T are length, breath and thickness

respectively. Under approximately the same operating conditions, nut size may play a significant role in processing. Therefore, the bulk nut sample was classified into three categories, namely large, medium and small based on their major axis dimension.

C) Determination of 100-nut weight and shell thickness

Three samples of 100 nuts were picked at random and weighed. The mass of 200 nuts was weighed individually and shelled using hand cum pedal operated shelling unit to separate kernels and shell. The weight of individual kernel was taken and corresponding shell thickness was found out at three points (i.e., top, middle and bottom) and the average value was taken.

D) Determination of porosity

The percentage porosity was calculated using the formula

$$Pt = ((P_1 - P_2)/P_1) \times 100$$

Where

Pt = porosity of raw nuts

P_1 = initial head difference in the porosity apparatus (pressure), cm

P_2 = final head difference in the porosity apparatus (pressure), cm

The experiment was replicated three times with different samples every time and the average was calculated.

Determination of bulk density and true density

The bulk density (ρb) was calculated from the mass and volume. The true density (ρ_t) was calculated from the experimental values of bulk density and porosity (P_t) at corresponding moisture contents using the following relation

$$\rho t = \rho_b/1\text{-}Pt$$

Determination of co-efficient of friction

The apparatus used in the friction studies consisted of a frictionless pulley fitted on a frame, a frictionless cylindrical container, loading pan and test surfaces. The cylinder was filled with cashewnuts and placed on the horizontal test surface. Weights were then added to the loading pan until the cylinder began to slide along the test surface. The normal force applied N_f was the weight of the nuts in the cylinder and the friction force F was the weight added to the pan. The co-efficient of static friction was calculated as $\mu = F/N_f$. The experiment was performed at different moisture contents of cashew nut using test surfaces of cardboard, galvanised iron sheet, aluminium sheet and glass with three replications.

G) Equilibrium moisture content of raw cashew nut

Equilibrium moisture content of raw cashew nut was determined by static method at constant temperature (30°C) and different relative humidity. The various relative humidity were obtained by using different saturated salt solutions. Initially the raw cashew nuts were cleaned to remove adhering dirt and dust. Initial moisture content of raw cashew nuts was found out by toluene distillation method. Known weights of nut samples in duplicate were placed in aluminium boxes and were kept inside the desiccators containing saturated salt solution at the bottom. The desiccators were kept inside a chamber maintained at 30°C. The weight of raw cashew nuts was taken at constant intervals. The experiment continued (5 months) till the constant weights were obtained. The equilibrium moisture content of raw cashew nuts at different relative humidities was determined at 30°C (Table 7.18).

Table 7.18: Equilibrium moisture content of raw cashew nuts at various relative humidities

Saturated salt solutions	Relative Humidity (%)	EMC (% db)
Potassium acetate	26.83	1.669
Potassium carbonate	43.91	3.371
Sodium nitrite	61.17	5.167
Sodium chloride	74.17	7.148
Potassium chromate	81.33	10.786*

* Mild fungus infestation started after 28 days of commencement of experiment.

H) Design aspects - Gravity separator

The basic difference in density of good and spoiled nut is taken into consideration while designing gravity separator. A gravity separator model (Fig. 7.1) with aluminium as construction material was designed considering the mechanical properties of raw nut, coefficient of internal friction and ease of fabrication. It is a rectangular box with three outlets on opposite side of feed end situated at equal distance. The whole box rest on central shaft, which revolves inside spherical holder, fixed to stand. Handles were provided to change side slope and end slope to have general slope towards corner.

I) Design aspects - Sieve separator

The change in minor axis dimension with respect to size is very much helpful to design sieve separator. A sieve separator (Fig. 7.2) was designed with three aluminium trays. Considering the major axis dimension of raw nut, the first tray was provided with 30 mm sieve diameter (round sieve) with a spacing of 15 mm between circumferences of sieves. Second tray had round sieves with 25 mm diameter and 15 mm spacing. Third tray is a collection tray passed through second tray. The overall dimension of oscillating trays was 60 x 40 cm i.e., sieve area. An adjusting mechanism was provided to change the slope to

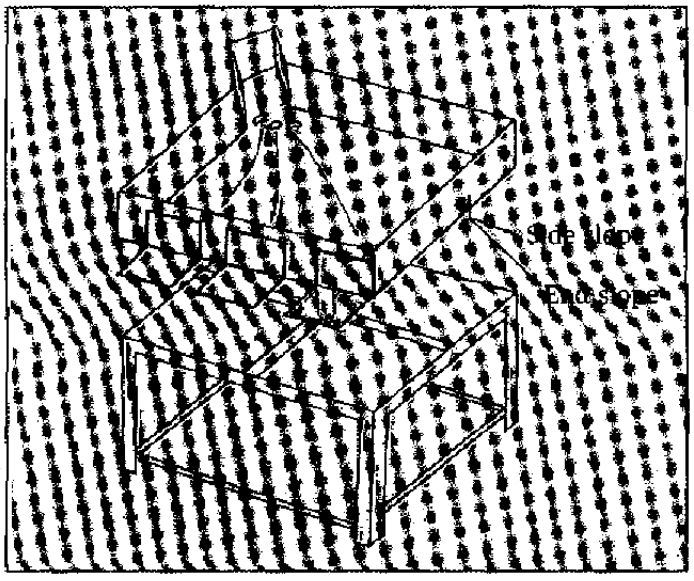


Fig. 7.1: Design aspects - Gravity separator

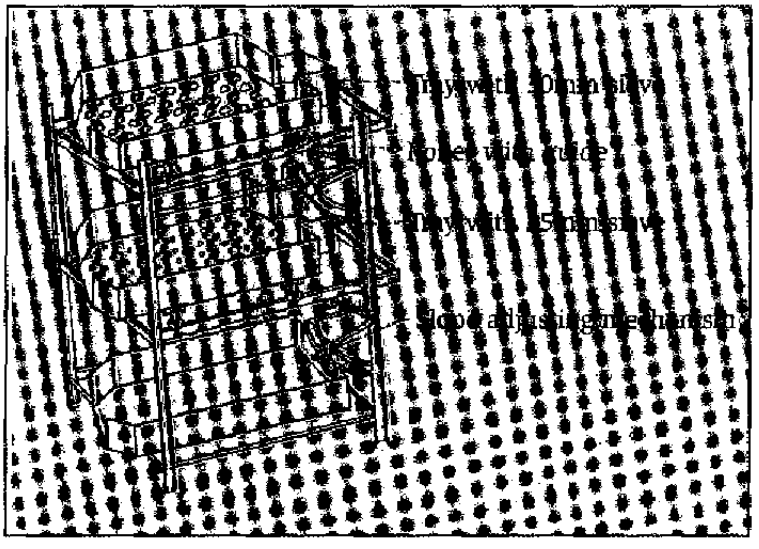


Fig. 7.2: Design aspects - Sieve separator

optimise for maximum separation efficiency. Trays were oscillated through guides and four wheels provided at the bottom of the trays to increase the rate of separation.

7.4.4 Results and Discussion

A) Dimensions of nuts and kernels

The size distribution of cashew nut is given in Table 7.19. In the sample, about 52% of the nuts had length ranging from 30-35mm (medium), whereas, 11.5% and 36.5% had length greater than 35mm (large) and less than 30mm (small) respectively. The mean values of 100 measurements at moisture content of 8.46 % db for the length, width, thickness and unit mass of the raw cashew nut were 31.00mm, 22.86mm, 16.91mm and 6.04g respectively. The corresponding values of the kernel were 24.674mm, 12.99mm, 12.063mm and 1.894g respectively. The co-efficient of correlation (Table 7.20) shows that the following

Table 7.19: Size distribution of cashew nuts and kernels at a moisture content of 8.46% d.b.

Size category	Ungraded	Large	Medium	Small
Length of nut, (mm)	23.86-40.06	> 35	30-35	< 30
Sample size				
By number (percentage)	200	23 (11.5)	104 (52.0)	73 (36.5)
By mass (percentage)	1193	162.80 (13.7)	668.86 (56.1)	361.34 (30.3)
Nut				
Length L, (mm)		36.96 ± 1.66	31.87 ± 1.13	27.97 ± 1.45
Width W, (mm)		24.68 ± 1.69	23.27 ± 1.60	21.71 ± 2.07
Thickness, T, (mm)		17.62 ± 2.05	17.30 ± 1.64	16.16 ± 1.66
Mass M, (g)		7.21 ± 2.25	6.45 ± 1.00	4.90 ± 0.84
Kernel				
Length L, (mm)		28.17 ± 1.59	25.42 ± 1.47	22.55 ± 1.44
Width W, (mm)		12.49 ± 1.83	12.87 ± 2.66	13.40 ± 2.83
Thickness, T, (mm)		12.56 ± 1.89	12.30 ± 1.35	11.58 ± 1.33
Mass M, (g)		2.35 ± 0.38	1.99 ± 0.36	1.61 ± 0.30
Shell				
Shell thickness		3.8 ± 1.12	4.04 ± 1.13	3.73 ± 0.42

Table 7.20: Ratio of nut and kernel dimensions at a moisture content of 8.46% d.b.

Parameters	Ratio				
	Mean	Minimum	Maximum	SD	Correlation
Length/width of nut	1.359	0.922	1.652	0.112	0.597*
Length/thickness of nut	1.846	1.285	2.597	0.218	0.330*
Length/mass of the nut	5.317	3.664	2.576	0.916	0.681*
Length/width of kernel	1.971	1.184	2.991	0.398	0.131*
Length/thickness of kernel	2.067	1.393	2.999	0.258	0.353*
Length/mass of kernel	13.474	7.341	2.152	0.291	0.719*
Length of nut/length of kernel	1.257	1.016	1.541	0.062	0.867*
Width of nut/length of kernel	1.824	1.247	3.020	0.362	0.213*
Thickness of nut/thickness of kernel	1.407	1.168	1.768	0.083	0.881*
Mass of nut/mass of kernel	3.204	2.659	4.668	0.374	0.638*

*Significant at 1% level

general expression can be used to describe the relationships among the dimensions of raw nuts

$$L = 1.359W = 1.846t = 5.317M$$

While the kernel showed the relationship among the dimensions and mass as

$$l = 1.971w = 2.067t = 13.474m$$

A higher mass ratio of 3.204 of nut to kernel indicates relatively lower yield of kernel per unit weight of raw cashew nut. The equivalent diameter of raw cashew nut and kernel are given in Table 7.21.

B) 100-nut weight and shell thickness

The mass of 100 nuts determined at different moisture content is shown in Fig.7.3. The mass of 100 raw nuts showed a linear increase with increasing moisture content and it bears the following relationship.

$$M_{100} = 577.966 + 7.543M_d \ (r = 0.986)$$

Shell thickness followed a linear relations with moisture gain. The absorbed moisture, c after saturating the inter space available in ho comb structure of shells moved to the inner skin kernel area. This may be the reason for raw cash nut to increase its volume immediately after soak in water.

C) Porosity of nuts

The porosity was evaluated for raw nuts an increased linearly from 48.03 to 52.33% when moisture content changed from 3.15% to 20.06% (Fig.7.4). The relationship between the porosity a moisture content for raw nut is given below:

$$P_t = 47.050 + 0.268\ M_d \ (r = 0.990)$$

A comparison of porosity of cashew nut w those of other grains revealed that it increased w moisture content similar to that of other grains.

Table 7.21: Equivalent diameter and sphericity of nut and kernel at a moisture content of 8.46% d.b.

	Equivalent diameter, (mm)		Sphericity	
	Range	Mean*	Range	Mean*
Raw nut	18.71-27.52	22.78 (1.78)	0.62-0.86	0.74 (0.04)
Kernel	11.82-19.73	15.56 (1.54)	0.54-0.81	0.63 (0.06)

* Average of 100 measurements; values in parentheses are SD

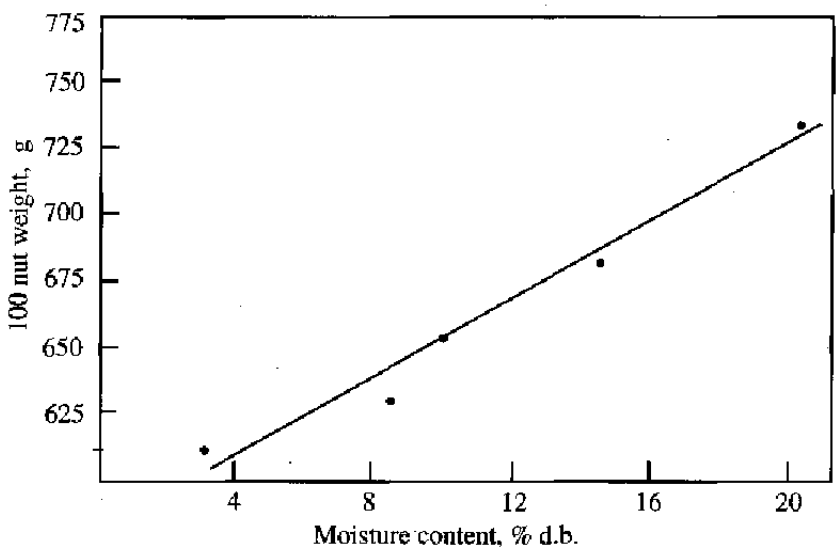


Fig 7.3: 100-nut weight as a function of moisture content

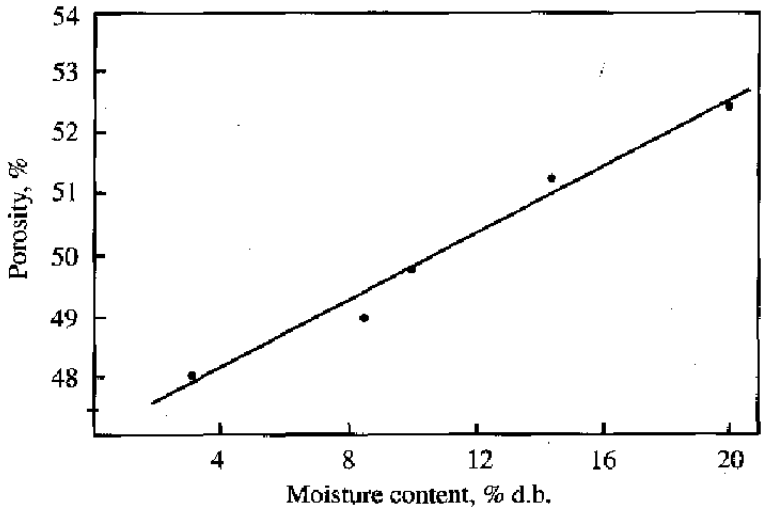


Fig 7.4: Porosity as a function of moisture content

D) Bulk density and true density

Effect of moisture content on bulk density of raw cashew nut was studied (Fig.7.5). The values of the bulk density at different moisture levels varied from 591.9 to 624.2 kg/m^3. The bulk density of nut bears the following relationship with moisture content.

$$\rho_b = 631.921 - 2081\ M_d \quad (r = 0.973)$$

The bulk density decreased with increase in moisture content. This shows that the increase in mass owing to moisture gain in the sample is lower than the accompanying volumetric expansion of the bulk.

The relationship between true density and moisture content is shown in Fig.7.6. The variation in true density with moisture content of raw cashew nut can be represented by the following equation.

$$\rho_t = 1192.71 + 2.295\ M_d \quad (r = 0.996)$$

The true density of nut found to increase linearly from 1201 - 1240 kg/m^3 with increase in moisture content from 3.15 to 20.06% db. This may be due to higher weight increase of nut in comparison to its volume expansion on moisture gain.

E) Co-efficient of internal friction

The static co-efficient of friction for raw cashew nut with respect to moisture content on four different surfaces is presented in Fig.7.7. The relationship between moisture content and static co-efficient of friction can be represented by the following equations

For glass

$$\mu_g = 0.172 + 0.004\ M_d \quad (r = 0.886)$$

Where, μg - co-efficient of friction against glass

For aluminium

$$\mu_{al} = 0.233 + 0.003\ M_d \quad (r = 0.956)$$

Where, μ_{al} - co-efficient of friction against aluminium

For Galvanised Iron

$$\mu_{gi} = 0.240 + 0.003\ M_d \quad (r = 0.946)$$

Where, μ_{gi} - co-efficient of friction against Galvanised Iron

For Cardboard

$$\mu_{cb} = 0.236 + 0.004\ M_d \quad (r = 0.979)$$

Where, μ_{cb} - co-efficient of friction against Cardboard

The static co-efficient of friction increased linearly with respect to moisture content for all four contact surfaces. The maximum friction was offered by cardboard followed by galvanised iron and aluminium. The glass offered least friction due to smooth and polished surface. The reason for the

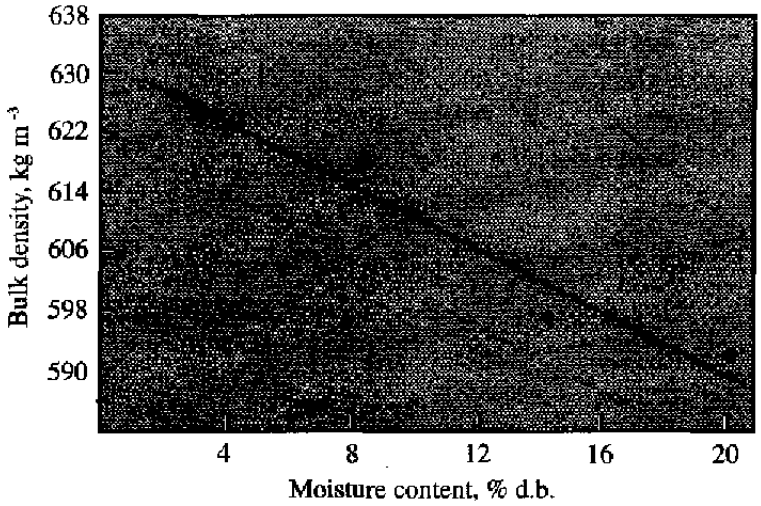


Fig.7.5: Bulk density as a function of moisture content

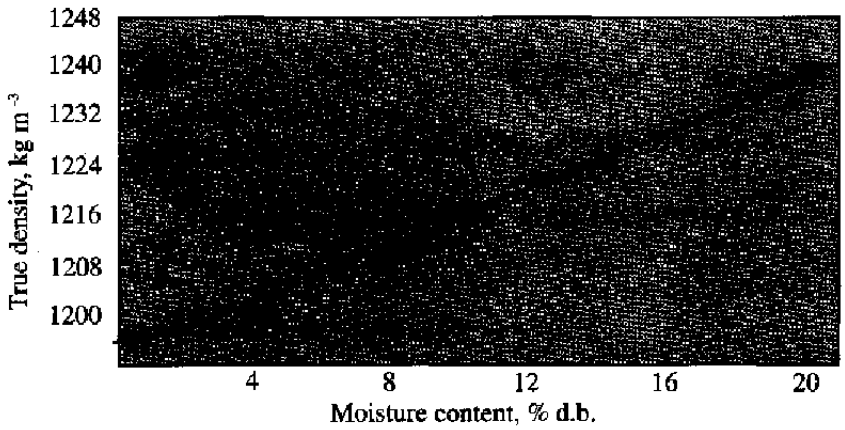


Fig.7.6:True density as a function of moisture content

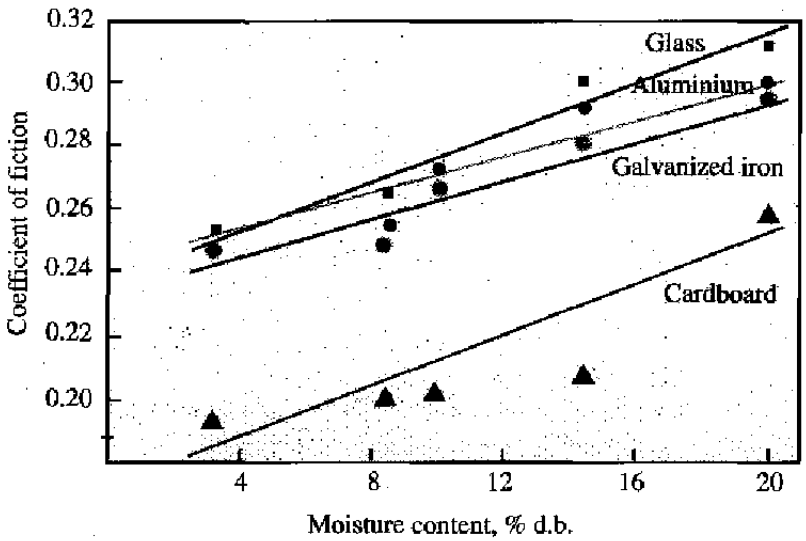


Fig.7.7: Coefficient of friction as a function of moisture content

increased static co-efficient of friction at higher moisture content may be owing to the water present in the nut offering a cohesive force on the surface of contact.

F) Equilibrium moisture content

The increase in the moisture content with the relative humidity exhibits desorption isotherm up to 74.12%, but at 81.33% it followed adsorption isotherm. Mould growth and deterioration took place after 28 days at 81.33% after the commencement of experiment. The data were fit in the Henderson's equation and by solving simultaneous equations the values of the constants were found to be 7.09×10^{-4} and 0.865 for c and n respectively.

G) Evaluation of grader

Experiments conducted with mixture of good and spoiled nuts keeping corner slopes of 5.02°, 10.16°, 15.56°, 21.34°, 27.79° and 35.29° revealed that in the first two slopes there was no movement of nuts even after vibration or tapping. Free movement occurred after 21° onwards only. Cashew nuts after moving from feed end got accumulated at farthermost outlet area. The surface characteristics and weight difference play vital role in gravity separator as far as the separation efficiency is concerned. The weight of good and spoiled nuts were not differing much and sometimes, spoiled nuts of particular origin weighed more than good nuts. Further, the surface characteristics of good and bad nuts did not vary significantly. The separation efficiency of gravity separator was low.

Keeping first and second trays in three angular positions the performance evaluation of sieve separator was conducted. The angular positions were 4°, 11° and 14°. The small, medium and big size nuts were segregated manually and mixed in 1:2:3 proportion and used in the experiment. As the efficiency of sieve separator at position 1 and 3 of second tray appeared low, the 2nd position of tray with various positions of first tray was compared. Better result was achieved with 11° first tray angle and 14° second tray angle. In round sieves, the separation took place based on the orientation of nuts and occasional clogging of nuts reduced the separation efficiency. Therefore alternative design of rotary grader is suggested.

The results of gravity and sieve separator reveal that the efficiency of separation is low mainly due to

- Insignificant variation in surface characteristics of good and bad nuts
- Changing surface characteristics with respect to moisture content of nut
- Higher weight of bad nuts compared to good nuts of certain origin
- Irregular shape of raw nuts and the orientation while moving
- Clogging of nuts in sieve as the minor axis is not uniform throughout its length

7.4.5 Conclusions

- The mass of 100 nuts and true density of raw cashew nuts increased with increased moisture content. The porosity and bulk density decreased linearly with the increased moisture content.
- The co-efficient of friction on various surfaces increased with increased moisture content. Cardboard as surface for sliding offered the maximum friction followed by galvanised iron, aluminium and glass.
- The average length, width, thickness of raw cashew nuts at 8.46% was 31.000, 22.860 and 16.914 mm respectively, while the corresponding values of kernels were 24.674, 12.987 and 12.063 mm. About 52% of the nuts had length between 30-35mm whereas, 11.5% and 36.5% of nuts categorized under > 35mm and < 30mm respectively. The average unit mass of the nut and kernel was 5.964 and 1.894g respectively.
- The average sphericity of raw cashew nut and kernel at moisture content 8.46% db were 0.737 and 0.633 respectively. Mass of 100 raw nuts varied between 610.6 g to 735.1 g and it increased linearly with increased moisture content.
- The porosity increased from 48.03 to 52.33%, while the bulk density decreased from 624.2kg/m^3 to 591.9 kg/m^3 as the moisture content increased from 3.15% to 20.06% db. The true

density of nuts followed a linear correlation with moisture content. It increased from 1.201g/cc to 1.240g/cc with increase in moisture from 3.15% to 20.06% db.

- The static co-efficient of friction for nuts increased linearly with moisture content irrespective of surface employed, namely, glass (0.19 to 0.25), aluminium (0.25 to 0.30), galvanised iron (0.25 to 0.30) and cardboard (0.25-0.31).

- The equilibrium moisture content of raw cashew nuts increased with the relative humidity and exhibited desorption isotherm up to 74.12% but at 81.33% it followed adsorption isotherm. Mould growth and deterioration occurred after 28 days at 81.33% after the commencement of experiment.

- Gravity separator was designed taking into consideration of the variation in kinetic energy while in movement along the slope. The trials conducted with three different end slopes i.e., 4°, 7°, 11° revealed that the separation efficiency was not up to the mark primarily due to similar smoothness of raw nut irrespective of its quality.

- A sieve separator was developed on the basis of the relationship between the sphericity and the nut size. As the curvature of side varied with size of the nut, the minor axis dimension was taken into consideration for sieve design. Due to the irregular shape, nut had different orientation while moving towards sieve hole resulting in clogging which lowered the separation efficiency.

- In view of lower separation efficiency in gravity and sieve separator, a rotary grader with four different sieve segments which can be operated both manually and through electrical motor is suggested to grade the raw nuts based on size.

7.5: Design, development and performance evaluation of improved cashew nut sheller

Project Leader	:	**D. Balasubramanian**
Project No.	:	**4.5**
Project Duration	:	**2000-2001**

7.5.1 Introduction

Cashew processing as an industry had its beginning in Mangalore, Karnataka. But soon it shifted to Quilon in Kerala, which later became the nucleus of cashew trade. The pioneering spirit of the early entrepreneurs and the unsurpassed skills of Indian women in extracting whole kernels from the nuts were the major factors influencing birth and growth of the industry in India. Preparation of cashew kernels for trade and export is an intricate procedure compared to that of other edible nuts. Raw nuts are pretreated (drum roasting/ oil bath/ steam boiling) to facilitate cracking [redacted] and dried for *de-husking*. *Shelling* [redacted] various sizes of nuts. This shelling unit can be [redacted] to actuate the disc. This aids in opening twin blades and split the nut.

B) Operation

The raw cashew nut is placed in between blades with its notched portion facing the holder blade and existing hand cum pedal operated sheller.

B) Performance evaluation

Raw nuts are purchased from local market (Sullia origin) and graded manually into small (20-22mm), medium (≤ 23 -25 mm) and big (≥ 26 mm) based on its minor dimension. The graded raw nuts are steamed at 4 kgm^{-2} in baby boiler with centralized steam supply system for 16 min. Steam boiled nuts are dried for 20 h at ambient environment. About 5 kg of pretreated nuts of various sizes viz., small, medium and big are shelled separately by semi skilled operators. The data on operational capacity, wholes/broken ratio, qualitative efficiency quantitative efficiency and [redacted] The sheller design accommodates nut feeding from both the sides.

C) Performance

The average operational capacity of improve cashew nut sheller is 9.3 Kg /h. The average qualitati efficiency of the unit in terms of wholes and broken

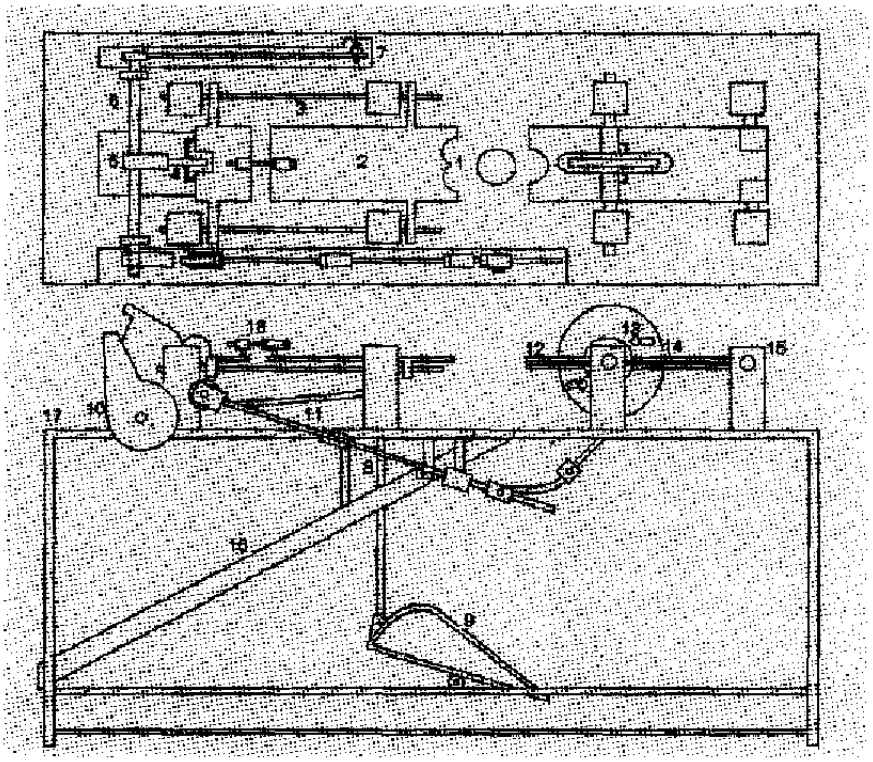


Fig. 7.8: Modified cahsewnut sheller

1. Holder blade 2. Sliding arm 3. Guide rod 4. Bearing 5. Holder cam 6. Driving shaft 7. Lever arm 8. Connecting r 9. Pedal 10. Split cam 11. Sliding rod 12. Twin blade 13. Eccentric joint 14. Central disc 15. Support with hin 16. Spout 17. Base plate 18. Nut adjuster

disc and blade arm are joined together through cotter pin inserted into the top and bottom eccentric holes of the disc. The radial movement of disk makes the twin blades to move apart due to the hinge and eccentric joint. The sliding rod with bearing at one end transfers motion to disc. This assembly converts the linear to radial movement.

The linkage assembly has two cams, one of which is fitted to the mid point transfers motion to nut holding arm. The second cam is fixed at the extreme point of the driving shaft in order to actuate split blades. The cam at centre of shaft is designed in such a way that it gently pushes the sliding arm until the attached blade penetrate and slips not allowing the nut holder assembly to return. Exactly at the slipping point onwards the split cam pushes the sliding rod in order to actuate the disc. This aids in opening twin blades and split the nut.

B) Operation

The raw cashew nut is placed in between blades with its notched portion facing the holder blade and convex side resting on the edges of twin blades. Wh the pedal is pressed, sliding arm moves front and hol the nut. Further pressing makes the cam to slip a allows the second cam to push the sliding rod to rota the disc to a set angle. This helps the outwa movement of twin blades resulting in splitting of shel The compression spring provided ensures the whc assembly back in position after the release of for applied on pedal.

The distance between holder and twin blad assembly decides the whole kernel yield. An adjusti mechanism is provided on the top of the sliding ar for various sizes of nuts. This shelling unit can operated in a sitting posture reducing the drudge experienced in hand cum pedal operated shelli machine. The sheller design accommodates nut feedi from both the sides.

C) Performance

The average operational capacity of improv cashew nut sheller is 9.3 Kg /h. The average qualitati efficiency of the unit in terms of wholes and broken

9.84. The constant movement of blades and splitting angle of twin blades enabled the penetration of blades upto inner edge of shell. This reduces the kernel damage to a greater extent. Since whole kernel yield at shelling level is one of the factors deciding economic efficiency, the increase in whole kernel yield in shelling using improved unit is advantageous. The overall quantitative efficiency is 87.52%. This is due to lack of operator's experience with newly developed shelling unit. An increasing trend in operational capacity, w/b ratio and shelling efficiency, when allowed to shell the nuts continuously for certain period was observed. The sitting posture reduced the operator's drudgery. This clearly indicated that the operators can improve the operational performance after gaining experience.

D) Operational capacity

The data on production capacity showed that the improved and existing shellers do not differ with respect of operators. Although operators are not experienced with the newly developed sheller, the same production capacity of improved sheller over existing unit gives a positive sign of improving individual performance. With respect to size of the nut, the types of shellers are significant at 5% level. It has been found out that nuts/kg of the small (20-22mm), medium (> 23 -25 mm) and big (> 26 mm) size nuts ranges from 180-190, 150-160 and 120-130 nuts per kg respectively. Therefore, it is obvious that the capacity of the sheller is highly influenced by the size of the nut. The simple locknut and bolt assembly to adjust the distance between the holder and splitting blade does not require special skill.

E) Wholes / Broken ratio

The average values of qualitative efficiency for improved and hand cum pedal operated sheller is 9.83 and 4.69 respectively. In the existing sheller, the operator has to manipulate the size of the nut and the operation to extract the whole kernel. But in the improved design, the constant movement of holder and splitting blades ensures the higher whole kernel yield. The variation in the ratio with respect to operator is non significant. But the size of the nut plays vital role to obtain better qualitative efficiency.

F) Quantitative / Shelling efficiency

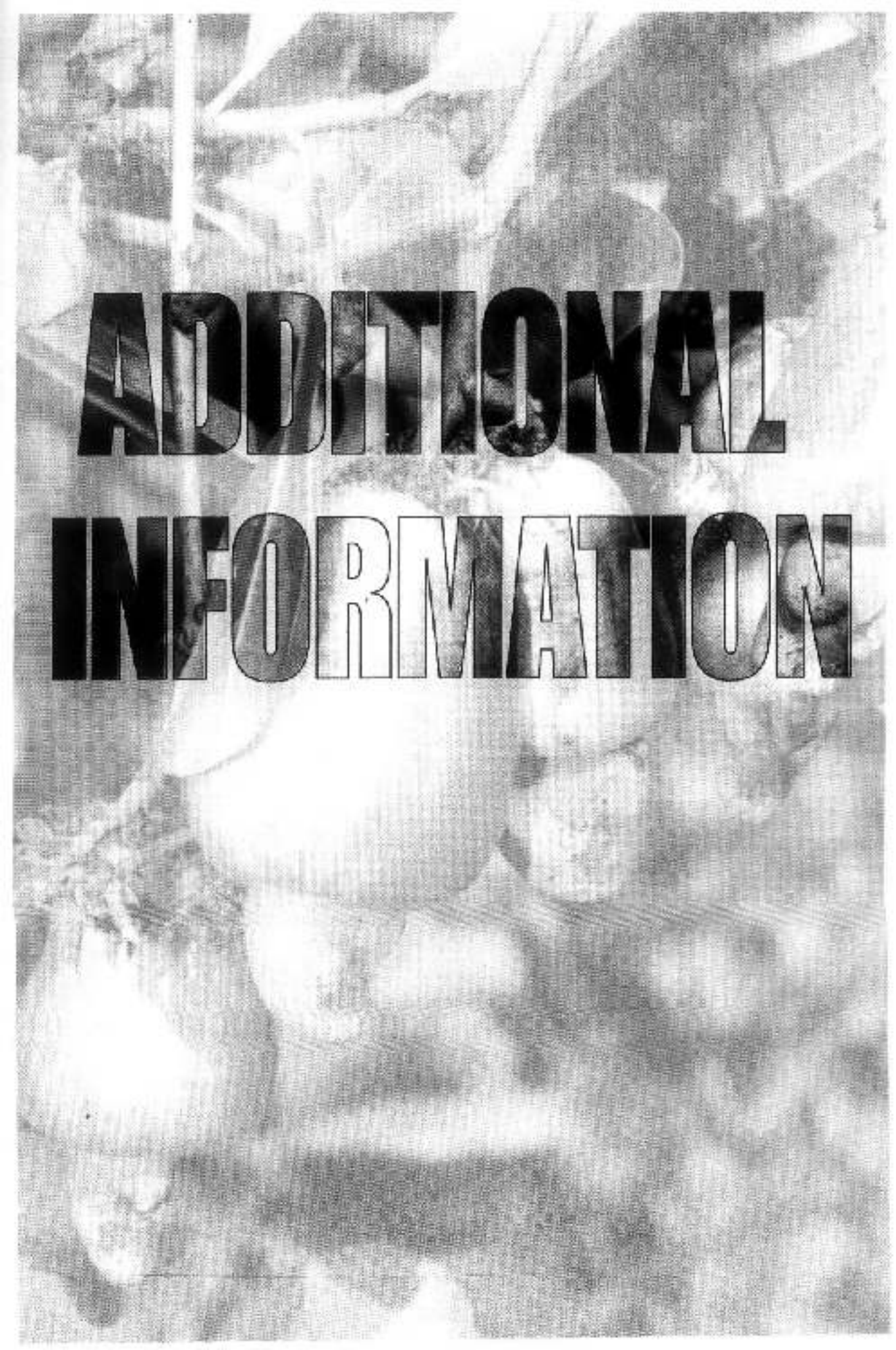
The quantitative efficiency of both improved and hand cum pedal operated units are non significant with respect to operator and size. The difference in overall efficiency between two shellers is due to the lack of experience of the semi-skilled personnel with newly developed unit.

G) Rate of production

Increasing trend in shelling rate is observed in case of improved sheller. The nut feeding and pedal operation to hold and split open should follow uniform time interval for better production rate. The simple pedal operation and feeding nut make the operators to get adjusted with unit in shorter period and resulted in increasing production. In the existing sheller, the operators showed better performance in the beginning, but as the time elapses a declining production rate is noticed. The continuous operation of pedal according to the size of the nut and lifting the lever to open, led to fatigue in shorter period. Based on the degree of fatigue, the individual performance declines with respect to time.

7.5.5 Conclusions

- A single operation cam type pedal operated cashew nut sheller has been developed to overcome the drudgery experienced with hand cum pedal operated sheller. The developed unit costs 17% more than existing sheller.
- The gap between two blades can be adjusted according to the size of the nuts. In order to avoid constant readjustments, the raw nuts have to be graded based on size and nuts of similar size can be taken at a time.
- The wear and tear of various parts of newly developed shelling unit has to be observed in a long run and the remedial measure needs to be worked out.
- As cutting with mechanical aid showed considerable improvement in yield of whole kernels, an attempt needs to be made to develop a high performance sheller with mechanical feeding facility for the nuts and synchronized power operation of the cutter.


ADDITIONAL
INFORMATION

8. EDUCATION AND TRAINING

A training programme on Vegetative Propagation of Cashew was conducted on 3rd and 4th September, 2001, in which trainees were made to acquire the skill of softwood grafting. A total of 34 trainees sponsored by Development Departments from Karnataka, Kerala, Tamil Nadu, Andhra Pradesh and Meghalaya participated in the training programme.

A total of 18 IVLP-KVK staff of CPCRI, Kasaragod were trained on cashew cultivation aspects at CPCRI, Kasaragod on 3-1-2002.

Three days refresher course on 'Cashew Production Technology' was organised during 17-19, January, 2002 in which nine trainees sponsored by Development Departments of Karnataka and Kerala were trained.

Five days special training course for KVK staff was organised during 4-8, March, 2002. Trainees from Kerala, Karnataka and Tamil Nadu were provided in-depth training on various aspects of cashew production technology.

9. LINKAGES / COLLABORATION

1. In collaboration with PDBC, Bangalore, EAG studies were undertaken to find out the source of kairomones and pheromones for CSRB / TMB.
2. DNA finger printing of the accessions from NCGB has been taken up in collaboration with UAS, Bangalore.
3. Soil and water conservation / plant protection campaigns were conducted in collaboration with Shri Kshetra Dharmasthala Rural Development Project, Dharmasthala. The financial aid was provided by DCCD, Kochi.
4. Annual Cashew day was organised in collaboration with Shri Kshethra Dharmasthala Rural Development Project, Dharmasthala, Shri Durga Charitable Society, Keyyur and Bharathiya Kissan Sangha, Puttur, Sullia and Udupi. The financial aid was provided by DCCD, Kochi.
5. Eightynine demonstration plots were laid out with financial support of DCCD, Kochi of which eleven were under high density planting system.
6. In collaboration with CPCRI, Kasaragod, training programme on 'Cashew Production Technology' was organised at CPCRI, Kasaragod, for IVLP-KVK staff of CPCRI, Kasaragod.

10. AICRP CENTRES

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Fax No. 04143-60970

11. LIST OF PUBLICATIONS

11.1 Research/Popular Publications

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Balasubramanian, D. 2001. Cashew processing industries in India - Overall Analysis. *The Cashew.* **15**(2): 14-20.

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Thimmappaiah and Shirly R. A. 2001. Status of micropropagation in cashew. Proceedings of XV Biennial Workshop Oct. 18-20, 2001. All India Coordinated Research Project on Cashew. P. 44-53.

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Nampoothiri, K.U.K., Kumaran, P.M. and Swamy, K.R.M. 2002. Plantation Crops. In: Crop Genetic Resources: An Indian Perspective (Ed. K. Tyagi). Indian Society of Plant Genetic Resources, NBPGR, New Delhi.

Sundararaju, D., Raviprasad, T.N. and Bhat, P.S. 1999. Pests of cashew and their integrated management. Vol.6: 525-544. IPM System in Agriculture. Aditya Publication Pvt. Ltd., New Delhi.

1.4 Technical Reports / Bulletins / Compendia

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All India Coordinated Research Project on Cashew. 2001. Annual Report 2000-2001. National Research Centre for Cashew, Puttur, Karnataka. 118 pp.

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National Research Centre for Cashew. 2001. Cashew News. Newsletter Vol.6(1). Puttur, Karnataka. 8 pp.

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Swamy, K.R.M., Bhaskara Rao, E.V.V. and Bhat, M.G. 2002. Status of cashew gemrplasm collection in India. National Research Centre for Cashew. NRCC Tech. Bull. No. 7. 48 pp.

11.5 Extension bulletins / pamphlets

Bhat, P.S. and Venkattakumar, R. 2002. Questions and Answers on Cashew Production Technology (English) 12 pp.

Bhat, P.S. 2002. Questions and Answers on Cashew Production Technology (Kannada). 10 pp.

Bhat, P.S. 2002. Information Booklet. 5 pp.

Venkattakumar, R. 2002. Cashew Production Technology (Compendium of Lectures) - Lecture notes Series 13 (revised) 75 pp.

Venkattakumar, R., Yadukumar, N and Bhat, P.S. 2002. Cashew cultivation practices (revised) 4 pp.

Yadukumar, N. 2002. Soil and water conservation practices (Kannada) (revised) 4 pp.

Yadukumar, N. and Bhat, P.S. 2002. Cashew cultivation practices (Kannada) (revised) 6 pp.

NRCC Recommendation Leaflet No.1. 2002. Planting material for cashew. 2 pp.

NRCC Recommendation Leaflet No.2. Recommended varieties of cashew. 2 pp.

NRCC Recommendations Leaflet No.3. Climatic requirements of cashew. 2 pp.

NRCC Recommendations Leaflet No.4. Planting technology for cashew. 2 pp.

NRCC Recommendations Leaflet No.5. Soil and water conservation in cashew. 2 pp.

NRCC Recommendations Leaflet No.6. Manures and fertilizers for cashew. 2 pp.

NRCC Recommendations Leaflet No.7. Intercropping and mixed cropping in cashew. 2 pp.

NRCC Recommendations Leaflet No.8. High density planting of cashew. 2 pp.

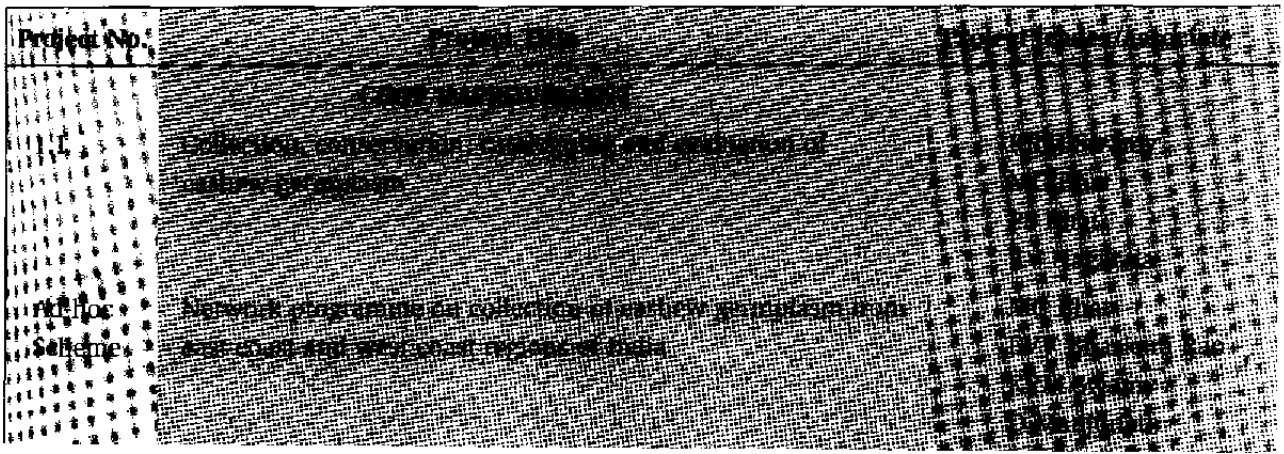
NRCC Recommendations Leaflet No.9. Canopy management in cashew. 2 pp.

NRCC Recommendations Leaflet No.10. Management of tea mosquito bug in cashew. 2 pp.

NRCC Recommendations Leaflet No.11. Management of cashew stem and root borer. 2 pp.

NRCC Recommendations Leaflet No.12. Cashew nut processing. 2 pp.

12. LIST OF ONGOING RESEARCH PROJECTS



Project No.	Project Title	Project leader/associate
Ad-hoc Scheme	Network programme on hybridisation in cashew	MG Bhat KRM Swamy
1.2	Varietal Improvement of Cashew	MG Bhat KRM Swamy KV Nagaraja
1.4	Regeneration of cashew through somatic embryogenesis and evaluation of micropropagated plants	Shirly R Anil Thimmappaiah
DBT Scheme	*In vitro* regeneration of cashew from mature tree explants	Thimmappaiah Shirly R Anil Sadhana P Hebbar
	CROP MANAGEMENT	
2.2	Planting systems and spacings trials in cashew	N Yadukumar
2.3	Canopy management studies in cashew	MG Nayak N Yadukumar
2.8	Efficacy of soil and water conservation with organic and inorganic manuring in cashew garden grown in sloppy areas	N Yadukumar
2.10	Crop regulation in cashew through plant growth regulators	MG Nayak KRM Swamy
Ad-hoc Scheme	Influence of fertigation on yield and quality of cashew	N Yadukumar
NATP	Developing integrated production packages for enhancing productivity of cashew	N Yadukumar TN Raviprasad KV Nagaraja SL Nandan CH Yajnesh M Geetha
	CROP PROTECTION	
3.4	Integrated pest management of cashew stem and root borer (CSRB)	TN Raviprasad PS Bhat D Sundararaju
3.5	Integrated pest management of tea mosquito bug (TMB)	D Sundararaju PS Bhat TN Raviprasad
3.6	Studies on determination of insecticide residues in cashew kernels	PS Bhat TN Raviprasad
3.7	Studies on pheromone of tea mosquito bug *Helopeltis antonii* S.	PS Bhat

Project No.	Project Title	Project leader/associate
	POST HARVEST TECHNOLOGY	
4.3	Design development and performance evaluation of improved cashewnut sheller.	D Balasubramanian
Ad-hoc	Value addition in cashew	KV Nagaraja S Padma
4.5	Standardisation of pmtocol for cashew apple utilization	S Bhuvaneswari KV Nagaraja M. Gangadhara Nayak
	TRANSFER OF TECHNOLOGY	
5.1	Research cum demonstration plots	R. Venkattakumar PS Bhat N Yadukumar
5.2	Impact of transfer of technology in cashew cultivation	R. Venkattakumar TN. Raviprasad
	STATISTICS	
6.1	Development of yield forecasting model	PD. Sreekanth EVV. Bhaskara Rao

13. IMPORTANT MEETINGS AND DECISIONS

13.1 Research Advisory Committee

1.	Dr. K.V. Ahamed Bavappa, FAO Consultant Karooth Villa, P.O. Kappur, Kumaranellur 679 552 Palakkad District, Kerala	Chariman
2.	Dr. R.T. Gunjate Reliance Petroleum Limited Horticulture Department E.O.2, Township, Motikhavadi 361 140 Jamnagar District (Gujarat)	Member
3.	Prof. A. Regupathy Professor of Entomology AC and RI, Coimbatore 641 003	Member
4.	Mr. P.P. Balasumbramanian Director Directorate of Cashewnut and Cocoa Development Govt. of India Ministry of Agriculture, (Dept. of Agri. Cooperation) 8th Floor, Kera Bhavan, Kochi 682 011, Kerala	Member

5.	Dr. B.R. Hedge (Retired Director of Research) 347, 10th Main, 7th Cross, NTI Layout Vidyaranyapura Bangalore 560 097	Member
6.	Dr. R.N. Pal Asst. Director General (PC) Indian Council of Agricultural Research Krishi Bhavan New Delhi 110 001	Member
7.	Dr. E.V.V. Bhaskara Rao Director NRC-Cashew, Puttur 574 202	Member
8.	Dr. K.R.M. Swamy Principal Scientist (Hort.) NRC-Cashew, Puttur 574 202 DK, Karnataka	Member-Secretary

Decisions:

- As the genetic variability reported in cashew is at moderate level, there is still scope to continue the germplasm collection. Bastar district in Chattisgarh may be surveyed for cashew germplasm during second fortnight of April 2002.
- Parents for hybridization during 2002-2003 season may be chosen for complimentary characters (shelling per cent - > 30%, weight/nut - 7 - 9 g, weight/apple - > 60 g; synchronization of flowering in female and male parents).
- A new project proposal on DNA finger printing of cashew may be submitted for consideration by DBT.
- Mechanical pruning in the case of hedge row system of planting and application of growth regulators through drip irrigation may be tried.
- In high density planting, vertical growth of the plant may be checked by detopping at a convenient height viz., 3-4 metres. Concept of training has to be changed so as to obtain a bushy growth.
- Vermicomposting method may be compared with Japanese method of composting, both cost-wise and nutritionally. Economics needs to be worked out.
- The data on effectiveness of plant growth hormones for inducing bark callus and root initiation in CSRB infested trees needs to be compiled.
- Dr. Pathumal Beevi, KAU, Thrissur may be requested through Vice-Chancellor to formulate an ad-hoc project on the field control of TMB including influence of weather parameters.
- A new project may be proposed on mineral composition of kernels of recommended varieties of cashew.
- Possibility of dehydrating cashew apple and using it as a dry fruit may be explored.

13.2 Institute Management Committee

1.	Dr. E.V.V. Bhaskara Rao Director NRCC Puttur	Chairman
2	Dr. R.N. Pal Asst. Director General (PC) ICAR, Krishi Bhavan New Delhi 110 001	Member
3	Dr. KRM Swamy Principal Scientist, NRCC, Puttur	Member
4.	Dr. MG. Bhat Principal Scientist, NRCC, Puttur	Member
5.	Dr. TN Raviprasad Senior Scientist, NRCC, Puttur	Member
6.	Ms.Shirly Raichal Anil Scientist, NRCC, Puttur	Member
7.	Sri.K.Sanjeeva Asst.Administrative Officer NRCC, Puttur	Member-Secretary

The committee met twice on 10-12-2001 and 20.3.2002 during the year and reviewed the progress of research projects and ad-hoc projects. It accorded approval for the purchase of equipments.

13.3 Staff Research Council Meeting

Fourteenth Staff Research Council Meeting was held on 22-23 May 2001 and important decisions taken are furnished below:

- DNA-finger printing / molecular characterisation work at NRCC may be continued.
- Hormonal balance for each variety in relation to endogenous levels may be worked out while taking up regeneration studies.
- In canopy management studies, light interception at different levels (upper, middle and lower) may be recorded. Paclobutrazol may be used only after getting information on its acceptability in other countries.
- Occurrence of fungal pathogens from dried panicles, in the absence of TMB damage may be recorded.
- Protocols for estimation of residues of endosulfan in water, grass and soil in cashew eco-system may be developed.
- Mineral composition (Ca, Mg and Fe) of blends of pomace powder with cereals and legumes may be assessed.
- Training programme for research associates / senior research fellows of KVK's may be arranged. Campaign on high density planting system may be arranged.

13.4 Institute Joint Council (IJC)

Official Side

Dr. E.V.V. Bhaskara Rao	Chairman
Dr. N. Yadukumar	Member
Dr. M.G. Nayak	Member
Sri. K. Sanjeeva	Member
Sri. A.K. Shabaraya	Member
Sri. D. Balasubramanian	Secretary

Staff Side

Sri. K. Umanath	Member (CJSC)
Sri. K.R. Padmanabhan Nair	Member- Secretary
Smt. B. Jayashree	Member
Sri. K. Umashankar	Member
Sri. K. Narayana	Member
Sri. V. Sundara	Member

The IJC met 4 times during this year to discuss about staff welfare activities.

13.5 राजभाषा

राजभाषा कार्यान्वयन समिति

डॉ. ई.वी.वी. भास्कर राव	अध्यक्ष
डॉ. टी.एन. रविप्रसाद	सदस्य
डॉ. के.वी. नागराज	सदस्य
श्री मुरलीकृष्ण एच.	सदस्य
श्री प्रकाश जी. भट्ट	सदस्य
श्री शेखर नायक	सदस्य
श्री उमानाथ के.	सदस्य
श्री अन्नु के.	सदस्य
श्री सुंदरा	सदस्य
श्री उमानाथ शेट्टी	सदस्य
श्रीमति लीला एम.	सदस्य
श्री के. संजीवा	सचिव/संयोजक

राजभाषा कार्यान्वयन - गतिविधियाँ एवं प्रगती

केन्द्र में इस वर्ष के दौरान कार्यान्वयन समिति की चार बैठकें आयोजित की गयी। हर एक बैठक में राजभाषा प्रगती और कार्यान्वि संबंधी विषय पर चर्चा की गयी और लिएगए निर्णयों पर अमल भी की गयी। केन्द्र के विभिन्न अनुभागों में ज्यादा से ज्यादा हिन्दी की प्र करने की प्रयास जारी है।

जिन कर्मचारियों को हिन्दी में कार्यसाधक ज्ञान नहीं है ऐसे कर्मचारियों को केन्द्र में ही कक्षा चलाने की योजना की गयी है। फिला केन्द्र के दस कर्मचारी गृह मंत्रालय के राजभाषा विभाग द्वारा आयोजित पत्राचार प्रशिक्षण द्वारा हिन्दी शिक्षण पा रहें हैं।

हर साल के जैसे इस वर्ष भी केन्द्र में हिन्दी पखवाडा का आयोजन दिनांक 14.09.2001 से 28.09.2001 तक किया गया। पखव का उद्घाटन समारोह के अवसर पर केन्द्र के निदेशक डॉ. ई.वी.वी. भास्कर राव के अध्यक्षता में पुत्तूर नगर राजभाषा कार्यान्वयन समिति उद्घाटन श्री एच.जी.मैलारप्पा, डाक घर प्रवर अधीक्षक, पुत्तूर विभाग इनके करकमलों द्वारा हुआ। राष्ट्रीय काजू अनुसंधान केन्द्र इसके संयो रहेंगे। पुत्तूर नराकास में आस-पास के 22 सदस्य कार्यालय शामिल हैं। 28 नवंबर 2001 को पूत्तूर नराकास का प्रथम अर्धवार्षिक बै हुई। बैठक में राजभाषा विभाग के अधिकारी और अन्य गण्य व्यक्ति, सदस्यों को विभिन्न विषय पर मार्गदर्शन किए। पखवाडा के अंत आयोजीत अनेक स्पर्धाओं के विजेताओं को पुरस्कार वितरण किया गया। कार्यालयीन कार्य में हिन्दी की प्रयोग करने वालों को भी नकद पुरस वितरण किया गया।

14. PARTICIPATION IN SYMPOSIA / CONFERENCES / SEMINARS / MEETINGS

EVV Bhaskara Rao	Meeting of Working Group on Horticulture Development Programmes called by Dr. KL. Chadha at New Delhi	26 April 2001
EVV Bhaskara Rao	Meeting at Coconut Development Board Cochin to finalize the draft report of Working Group on Horticulture Development for formulation of X Five Year Plan	14 - 16 May 2001
KRM Swamy	Meeting on "Reviewing the Minimal Descriptor Lists of Horticultural Crops", NBPGR, New Delhi	18 June 2001
EVV Bhaskara Rao	National Seminar on Statistical Methods for Plantation Crops at CPCRI Regional Station, Kayangulam.	19 - 20 June 2001
EVV Bhaskara Rao	Workshop on Integrated National Agricultural Resources Information System (INARIS) at CPCRI, Kasaragod	29 June 2001
R Venkattakumar	Rural Programme Advisory Committee Meeting of Akashvani, Mangalore at ARS, Ullal	18 July 2001
EVV Bhaskara Rao	Meeting of Directors of ICAR Institutes at NBPGR Auditorium, New Delhi.	23 - 24 July 2001
KRM Swamy	Meeting on 'Endosulfan', Lalbaugh, Bangalore	10 August 2001
KRM Swamy	Meeting on "Problems in cashew production and marketing in Karnataka", Lalbaugh, Bangalore	10 August 2001
KRM Swamy	Meeting on "Cashew Production and Processing in Karnataka", DC Office, Mangalore	17 August 2001
EVV Bhaskara Rao MG Bhat KV Nagaraja N Yadukumar PS Bhat D Balasubramanian PD Sreekanth R Venkattakumar	Cashew Production Forecasting and Transfer of Technology efforts by DCCD, Kochi at NRCC, Puttur	7 September 2001
KRM Swamy	National Workshop on "Human Resources Development in Horticulture", Public Gardens, Hyderabad.	7-8 September 2001
EVV Bhaskara Rao	Advisory Committee Meeting of Silver Jubilee Celebrations / deliberations of HSR at Calicut, Kerala	7-8 October 2001

EVV Bhaskara Rao KRM Swamy MG Bhat KV Nagaraja Thimmappaiah N Yadukumar D Sundararaju MG Nayak PS Bhat TN Raviprasad Ms. Shirly Raichal Anil PD Sreekanth R Venkattakumar	XV Biennial Workshop of AICRP on Cashew, NRCC, Puttur	18-20 October 2001
EVV Bhaskara Rao	National Horticulture Conference organized by the Government of India at CGO Complex, New Delhi	16-17 November 2001
EVV Bhakara Rao	XV Biennial Workshop of AICRP on Palms at BCKV, Kalyani, West Bengal	19-21 November 2001
EVV Bhaskar Rao KV Nagaraja D Balasubramanian	National Symposium on Post Harvest Technologies for Agricultural Produce and Prospects for the Food Industry in Konkan Region - Organized by Association of Food Scientists and Technologies (India) in collaboration with ICAR Complex for Goa, at International Centre, Dona Paula, Goa	23-24 November 2001
EVV Bhaskara Rao	Third Meeting of ATIC Management Committee at CPCRI, Kasaragod, Kerala	29 November 2001
EVV Bhaskara Rao	XVIII Meeting of ICAR Regional Committee No. VIII at CTCRI, Trivandrum, Kerala	14-15 December 2001
EVV Bhaskara Rao KRM Swamy MG Bhat N Yadukumar D Sundararaju PS Bhat TN Raviprasad KV Nagaraja	First Annual Workshop of NATP on Cashew, NRCC, Puttur	20-21 December 2001
EVV Bhaskara Rao	Meeting of Directors of Horticulture Division / Directors of ICAR Institutes at NBPGR Auditorium, New Delhi	27-28 December 2001
EVV Bhaskara Rao	National Seminar on Horticultural Development in Chhattisgarh - Vision and Vistas at IGAU, Raipur	21-22 January 2002
KRM Swamy	National Workshop on, "Germplasm Management of Horticultural and Agroforestry Crops for sustainable utilization", NBPGR, New Delhi	27-28 Feburary 2002
EVV Bhaskara Rao	First Standing Committee Meeting of PLACROSYM-XV at Coffee Board, Bangalore	8 March 2002

15. FARMERS DAY/KRISHIMELA/EXHIBITION/ CAMPAIGNS

	Demonstration Farmers Meeting	16-7-2001
N Yadukumar PS Bhat TN Raviprasad R Venkattakumar	SWC / PP campaigns, Patlmunja, Belthangady, D.K. District	12-10-2001
	SWC / PP campaigns, Paddanadka, Belthangady, D.K. District	22-10-2001
	SWC / PP campaigns, Nittade, Belthangady, D.K. District	20-11-2001
	SWC / PP campaigns, Periyadka, Belthangady, D.K. District	22-11-2001
	Annual Cashew Day, NRCC, Expt. Stn. Shantigodu	14-3-2002
N Yadukumar R Venkattakumar	Seminar on Soil and Water Conservation and Inter cropping in Arecanut at Uppinangady, CA Bank	27-03-2002

16. RADIO TALKS / INTERVIEWS

PS Bhat	Pest control in cashew crop	16 April 2001
MG Bhat	Recommended varieties in coastal areas	16 August 2001
KRM Swamy	Advantages of planting grafts	30 October 2001
PS Bhat	Symptoms of diseases and control measures in cashew cultivation	10 December 2001

17. DELEGATION / TRAINING

KV Nagaraja PS Bhat	Agricultural Research Prioritization Techniques at NAARM, Hyderabad	25-30 June 2001
PD Sreekanth	Training on Visual Basic programming at IASRI New Delhi	16-28 July 2001
R Venkattakumar PD Sreekanth	[illegible] course, organised by Assistant Directorate of Implementation of Official Language, Mangalore	18 December 2001
K Sadeeva KRM Dharmanna Naik	Training programme on [illegible] awareness at [illegible]	[illegible] February 2002

18. DISTINGUISHED VISITORS

17-04-2001	Dr. S.B. Kadrekar Former Vice Chancellor Konkan Krishi Vidyapeeth, Dapoli, Maharasthra
20-7-2001	Dr. R.N. Pal DDG (Horticulture) I/C ICAR, Krishi Bhavan, New Delhi
18-8-2001	Mr. S.N. Shastry Secretary (Agri. and Hort.), Govt. of Karnataka
	Mr. Monappa Deputy Commissioner Dakshina Kannada, Karnataka
18-10-2001	Dr. G. Kallo DDG (Hort) ICAR, Krishi Bhavan, New Delhi
	Dr. P. Rethinam Chairman Coconut Development Board Kera Bhavan, Kochi - 682 014
15-2-2002	Dr. D. Rajagopal DI (PGS) UAS, GKVK, Bangalore - 560 065
18-3-2002	Dr. K.V. Ahamed Bavappa FAO Consultant and RAC Chairman Kumaranellur - 679 552, Kerala
	Dr. R.T. Gunjate Reliance Petroleum Limited RAC Member, Jamnagar District - 361 140, Gujarat
	Dr. B.R. Hegde Director of Research (Retried) RAC Member UAS, Bangalore - 560 065
	Dr. R.N. Pal ADG (PC), RAC Member ICAR, Krishi Bhavan, New Delhi

19. PERSONNEL

Managerial

Director (RMP) EVV. Bhaskara Rao

Scientific

Discipline	Scientist	Scientist (Sr.Scale)	Sr.Scientist	Pr.Scientist	Total
Agricultural Structures and Process Engg. (AS and PE)	S. Bhuvaneswari D. Balasubramanian*		--	--	2
Agricultural Entomology	--	P. Shivarama Bhat	D. Sundararaju T.N. Raviprasad	--	3
Agricultural Extension	R. Venkattakumar	--	--	--	1
Biochemistry (Pl.Sci.)	--	--	--	KV Nagaraja	1
Biotechnology	--	--	--	Thimmappaiah (Gen. and Cyto.)	1
Computer Application	PD. Sreekanth	--	--	--	1
Genetics and Cytogenetics	Shirly R Anil	--	--	--	1
Horticulture	Vacant		MG Nayak (Hort.)	KRM Swamy MG Bhat (Pl.Breeding)	4
Plant Physiology	Vacant*	--	--	--	-
Soil Science	--	--	--	N Yadukumar (Agronomy)	1
Soil and Water cons. Engg.	R. Rejani (from 17.10.2001)	--		--	1
Total (including vacant)					16

* Scientist (AS and PE) Temporarily adjusted against vacant post of Plant Physiology

TECHNICAL

Sri.K.Muralikrishna	Farm Superintendent (T-6)
Sri. P. Adbulla	Farm Superintendent (T-6)
Sri.H.Muralikrishna	Tech. Inf. Officer (T-6)
Sri.A.Padmanabha Hebbar	Tech. Officer (Elec.) (T-5)
Sri.R.Arulmony	Tech. Officer (lib.) (T-5)
Sri.Prakash G Bhat	Tech. Officer (T-5)
Sri.N.Manikandan	Technical Officer (T-5)

Sri R.Muthuraju, K.Seetharama, Lakshmipathi, R.Lakshmisha and KV.Ramesh Babu, R. Shekara Naik (T-4) Sardar Baig (T-4, upto 28.2.2002); K.R.Padmanabhan Nair, A.Poovappa Gowda (T-3); RaviShankar Prasad, K.Babu Poojary, Bejmi Veigus (T-2); KK.Madhavan, K.Umanath (T-1)

ADMINISTRATIVE

Sri.A.Keshava Shabaraya	Asst. Fin. and Accnts.Officer
Sri.K.Sanjeeva	Asst. Admn. Officer
Sri.K.M. Jayarama Naik	Asst.Admn. Officer (Stores)

Sri.V.Ahamed Bava (Sr.Stenographer); Smt.B.Jayashree, Sri.O.G.Varghese (Stenographers); Sri.MS.Satyanarayana (Assistant - retired on 31.10.2001), Sri.K.M.Lingaraju (Sr.Clerk); Mrs.M.Ratna Ranjani, Miss.Winne Lobo Sri.Rosario Mascarenhas (Sr.Clerks); Mrs.Leela (Sr.Clerk w.e.f. 1-11-2001), Sri.Uma Shankar (Jr-Clerk), Mrs. K Padmini Kutty (Jr-Clerk) (w.e.f. 9.11.2001); Sri.K.Balappa Gowda (Gestetner Operator)

20. MISCELLANEOUS

20.1 Graft production

During the year 2001-2002, a total of 1,33,256 softwood grafts of different cashew varieties worth Rs. 19,98,840 were distributed to farmers and other Development Agencies. These grafts were produced under the revolving fund schemes of ICAR and DCCD which are in operation at NRCC, Puttur.

During the year 2001-2002, a total of 1,43,714 softwood grafts of different cashew varieties were prepared of which over 1.00 lakh grafts would be available from both the revolving fund schemes for distribution during the planting season of 2002.

20.2 Weather data (2001-2002)

Months	Temperature (°C)		Humidity (%)		Total rainfall (mm)	Rainy days	Sunshine hours	Evapor-ation	Wind velocity /hour
	Max.	Min.	FN	AN					
Apr.2001	35.4	24.7	92	56	125.4	6	7.0	5.0	3.3
May	33.6	24.2	91	63	243.5	11	6.5	3.6	3.1
Jun.	29.0	23.0	96	84	900.5	26	0.3	2.7	3.3
Jul.	28.3	22.6	97	83	1098.1	34	1.3	2.5	3.0
Aug.	30.2	23.0	96	73	446.4	27	3.6	2.8	2.9
Sept.	30.8	23.1	96	74	140.7	9	3.0	3.4	2.4
Oct.	32.3	23.2	95	61	262.5	9	5.9	3.2	1.9
Nov.	33.3	22.1	93	54	112.5	6	7.2	3.2	1.6
Dec.	33.6	18.7	89	41	0.0	0	7.4	3.4	*
Jan.2002	33.9	19.1	91	44	0.0	0	7.9	4.1	*
Feb.	35.6	20.3	94	42	52.0	1	8.6	4.3	*
Mar.	37.0	23.3	92	39	5.3	1	7.9	5.7	*

* Anemometer was not working

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Mar.	37.0	23.3	92	39	5.3	1	7.9	5.7	*

कार्यकारी सारांश

काजू की उत्पादन और उत्पादकता बढ़ाने केलिए 1986 में रा.का.अनु. केन्द्र का स्थपना की गयी। इस केन्द्र का ध्येयोद्धेश में; इच्छुक गुणवाली व अधिक पैदादारवाली काजू किस्मों का विकसन, कृषि तकनीकों का मानकीकरण और प्रमाणित तकनीकों का हस्तांतरण शामिल है। कुल मिलाकर 22 अनुसंधान परियोजनाएँ जिनमें, तीन तदर्थ योजनाएँ, एक डी.बी.टी परियोजना, और एक एन.ए.टी.पी परियोजना इस केंद्र के ध्येयाध्देश प्राप्त करने केलिए चालू है। ये परियोजनाएँ फसल सुधार (6), फसल प्रबन्ध (6), फसल संरक्षण (4) कटाई उपरान्त प्रौध्योगिकी (3), तकनीकी हस्तांतरण (2) और सांख्यिकी (1) में हैं। इन विविध परियोजनाओं के विशेषताएँ सारांश रूप में निम्नलिखित है।

रोपण मौसम में, आन्द्र प्रदेश, कर्नाटका, केरला और महाराष्ट्रा से संग्रहित 18 कृतंक एक्सेशनों को राष्ट्रीय काजू जीन बैंक में रोपित किया गया, इसके साथ रोपित की गयी कुल एक्सेशनों की संख्या 451 हुई है। छः कटाई के उपरान्त, रा.का.जी.बैं. में स्थित 18 एक्सेशन्स का मूल्यांकन तथा चरित्रवर्णन आई.पी.जी.आर.आई. काजू वर्णन के अनुसार किया गया जिससे कुल चरित्रवर्णित एक्सेशनों की संख्या 269 हुई। प्रांतीय काजू जीन बैंक, रा.स.का.अनु.परियोजना तथा रा.का.जी.बैंक, पुत्तूर में संरक्षित एक्सेशनों को आइ. सी. संख्या एन.बी.पी.जी.आर., नई दिल्ली द्वारा दिया गया है। सूक्ष्मप्रसारण का अध्ययन इस साल भी जारी रहा। तैडयाजुरोन समाविष्टित एम.एस. माध्यम में प्रौढ वृक्षो से संग्रहित प्ररोह का कक्षीय कली प्रवर्धन (1-2 कली/एक्स प्लेंट) पाया गया। सूक्ष्मकलमन, पाँच एम.एम. लंबाई का सूक्ष्मकलम से भी सफल हुई। न्यूसेलस से उगाया कैलस; 2,4-डी तथा कैनेटिन समाविष्ट माध्यम में कम आवृत्ति में "सोमेटिक एमब्रियोजेनिसिस" पाया गया। भ्रूणीय कैलस निलंबित कलचरों में ज्यादा आवृत्ति का "सोमेटिक भ्रूणों" का पुनरुत्पादन दिखायी।

छाँटन और बिना छाँटन परिस्थितियों में काजू की पैदावार के बारे में जोर दी गयी। छाँटन और बिना छाँटन परिस्थितियों में 500 पेड़ प्रति हेक्टेर प्लाटों का उपज, पाँचवी और दसवी साल में क्रमशः, 156 पेड़ प्रति हेक्टेर प्लाटों से 2.38 तथा 1.98 गुना थी। तीन महीने में यूड्रिलस प्रभेद का केंचुआ से काजू बगानों से पुनश्चक्रयोग्य जैवमात्रा में गोबर मिश्र करके (कुल वाज़न का 15 प्रतिशत) वर्मीकॉम्पोस्ट तैयार कर सका।

काजू कॉंड और ज़ड छेदक का आकर्षकों को पहचानने के लिए पी.डी.बी.सी. बेंगलूर के साथ सहयोग बड़ाया गया है। "एलेक्ट्रोएण्टेनोग्रॉं" प्रयोगों में मिलित नर भृंगो तथा अमिलित मादा भृंगो ने काजू चिलके, फ्लॉस और गोंद की सार और वाष्पों को ज्यादा प्रतिक्रिया दिखायी। चाय मच्छर के विरुद्ध λ – सैहेलोत्रिन क्षेत्रीय परिस्थितियों में परिणामकारी पाया गया और कार्बारिल (0.1%) से मिलाजुला रहा। "टेलीनोमस" का अण्डा परजीविता आतिथेय अण्डा सांद्रता से धनात्मक और गरिष्ठ तापमान से ऋणात्मक संबंध दिखायी। काजू कॉंड और ज़ड छेदक तथा चाँय मच्छर नियंत्रण में क्रमशः इस्तमाल किये गये लिंडेन और एण्डोसल्फॉन का विषलेश; दक्षिण कन्नडा जिले के कृषकों के प्लॉट से संग्रहित कच्चा गुटलीयों में नही पाया गया।

काजू गरी के छोटे टुकडों को शक्कर और विविध सुस्वाद (वेनिल्ला, इलायची, अद्रक तथा लवंग) लेपित करके आठ महीने तक बिना स्वभावनष्ट रख सका। इलायची सुस्वादित, केसर वर्ण का छोटे टुकडे निर्णायक गण को अत्यंत पसंद थे। डैयास्टेस किण्व से काजू सेब पोमेस का शर्करपिष्ट को जीर्णित नहीं कर सका। इससे पता चला कि शर्करपिष्ठ का अंश जीर्णयोग्य नहीं है। काजू सेब पौडर को 10 प्रतिशत तक अनाज और दाल में स्वभाव के नष्ट किए बिना मिश्रण कर सका। 'क्याम' आधारित एक प्रकियाधारित पेडल चालित काजू गुटली शेल्लर को, वर्तमान में इस्तमाल किये जा रहे हाथ और पेडल चालित शेल्लर का श्रम कम करने केलिए विकसित किया गया है। काजू उपज की अंदाज़ा करने के लिये, "अनुमान मॉंडेल" पूरे भारत तथा विविध काजू उगाने वाली राज्यों के लिए संपादित किए गए हैं।

घन सांद्रता व्यवस्था पर इस साल आठ मॉंडल काजू क्लोनल बगाँनों को स्थापित करने से प्रात्यक्षिकी प्लाटों की कुल संख्या 89 हुई है। चार जगह में श्री क्षेत्र धर्मस्थल ग्रामीण विकास परियोजना के सहयोग में आयोजित "जल और मिट्टी संरक्षण तथा कीट नियंत्रण जनांदोलन" को अतीव अनुकिया मिला जिनमें 450 कृषकों शामील हुए थे। काजू उत्पादन तकनिकी और काजू में कायिक प्रवर्धन में, तीन टोलीयों में प्रत्यशियों को प्रशिक्षण कार्यक्रम आयोजित था। काजू कृषि की आधुनिक तकनीकों के जानकारी देकर कृषकों का ज्ञानवृद्धी करने हेतु "वार्षिक काजू दिवस" शांतिगोडु की प्रायोगिक क्षेत्र में व्यवास्थित किए गए थे, जिसमें 20 गाँव के प्रतिनिधिक 120 कृषकों ने भाग लिये थे।