

वार्षिक प्रतिवेदन
ANNUAL REPORT
2000-2001



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

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



	PAGE No.
भूमिका	05 - 06
PREFACE	07
EXECUTIVE SUMMARY	09 - 10
INTRODUCTION	11 - 15
RESEARCH ACHIEVEMENTS	17 - 94
1. CROP IMPROVEMENT	19 - 33
2. CROP MANAGEMENT	35 - 50
3. CROP PROTECTION	51 - 59
4. POST HARVEST TECHNOLOGY	61 - 65
5. TRANSFER OF TECHNOLOGY	67 - 68
6. CONCLUDED PROJECTS	69 - 94
ADDITIONAL INFORMATION	95 - 117
सारांश	118 - 119

भूमिका

इस वार्षिक प्रतिवेदन 2000-2001 में अलग अलग अनुसंधान परियोजनाओं में हुए प्रगति का संक्षेपण दिया गया है। अब तक राष्ट्रीय काजू जीन बैंक में रोपित 433 एक्सेशनस से ऐ.पी.जी.आर.ऐ. सिफारिश के अनुसार 255 को चरित्रवर्णन किया गया तथा केटलाग बनाया गया।

यू.ए.एस. बैंगलूर के सहयोग में 153 एक्सेशनस का डी.एन.ए. फिंगरप्रिंटिंग हुआ, जिस से यह प्रकटित हुआ कि काजू जननद्रव्य में विविधता पहले समझे जैसे सीमित नहीं था लेकिन साधारण रूप से था। मूल्यांकित विशिष्ट जननद्रव्य में M 76/2 तथा 13/5-कोडूर दस साल का संचयी उपज के आधार पर उत्तम पाया गया।

वी.आर.ऐ - 2 तथा एच-4-7, का पत्ता खण्डों से कैलस उत्पत्ति पाया गया। क्षेत्र रोपित परखनली वर्धित पौधा साधारण पौधों से उत्कृष्ट पाया गया और सामान्य रूप से पुष्पण दिखाया।

साधारण घनत्व प्लॉट (156 पेड/हेक्टर) के तुलन में उच्च घनत्व रोपण पद्धति लाभदायक रहा, और 384, 312, 236 पेड/हेक्टर प्लॉटों में 970, 893 तथा 625 किलो/हेक्टर उपज प्राप्त हुआ जो साधारण घनत्व प्लॉट का उपज (472 किलो/हेक्टर) से अधिक रहा। चापाकार बाँधन तथा नारियल छिलका गाड़ने से उपज में 2 से 3 गुना बड़ोत्री हुआ।

काजू काँड और जड़ छेदक (CSR) नियंत्रण के लिए कैरोमोनस प्रयोगों में काजू छिलके और फ्रॉस से मिले सार तथा बाष्पशील वस्तु का स्वरूप GC-MS द्वारा पहचाना गया। पौधस्वच्छता जारी रखने से छेदक पीडित प्लॉट में कीटसंख्या में कमी आई। अण्डनिक्षेपण निवारण के साथ साथ एक नया कीटनाशक इमिडाक्लोप्रिड ने चाय मच्छर का शिशुकीट तथा वयस्क कीटों पर बेहतर अवशिष्ट क्रिया व्यक्त किया।

काजू टुकड़ों से बने खाद्यस्वीकृत काजू स्त्रेड $< 0^{\circ}\text{C}$ और $6 - 13^{\circ}\text{C}$ तापमान में छः महीने तक संचयी आयु दिखाई।

काजू टुकड़ों को निर्वसीकरण करने से भी, काजू स्त्रेड का खाद्य स्वीकृति में फ़रक नहीं आई जिससे कैलोरी आशंकित ग्राहकों को सुविधा होगी।

डी.सी.सी.डी. कोच्ची के आर्थिक सहायता से उच्च घनत्व रोपण पद्धति का तीन बगानो कृषकों का प्लॉटों में स्थापित किया गया। के.जे.पी. फौंडेशन तिरुवनंतपुरम; एस.के.डी.आर.डी.पि, धर्मस्थल और श्री दुर्गा चारिटेबल ट्रस्ट, केय्यूर जैसे गैर सरकारी संस्थावो के सहयोग से मिट्टी और जल संरक्षण तथा कीट नियंत्रण अभियान आयोजित थे, जिसमे 500 तक कृषिकों भाग लिए।

मैं अपने सभी सहकर्मियों, जिन्होंने अनुसंधान परियोजनाओं में लगन से भाग लेकर इस वार्षिक प्रतिवेदन के लिए आँखडें पेश किए हैं उनको हार्दिक आभार प्रकट करना चाहता हूँ।

इस साल का उपलब्धियों को संक्षिप्त रूप में प्रस्तुत करने के लिए मैं संपादकीय समिति को कृतज्ञ हूँ।

ई.वी.वी. भास्कर राव

(ई.वी.वी. भास्कर राव)

निदेशक

पुत्तूर
31 जुलाई, 2001

PREFACE

The progress made in different research projects undertaken at this centre during 2000-2001 is summarised in this Annual Report. Out of 433 accessions planted so far in NCGB, 255 have been characterized as per IPGRI descriptors and catalogued. In collaboration with UAS, Bangalore, DNA finger printing of 153 accessions were taken up and the results revealed that diversity in cashew germplasm is moderate and not narrow as reported earlier. Among elite germplasm evaluated, M 76/2 and 13/5 Kodur were best considering cumulative yield of ten harvests. Callus was induced in leaf segments from *in vitro* cultures of VRI-2 and H 4-7. Field planted micropropagated plants were superior to control and showed normal flowering pattern.

High density system of planting was found to be profitable with yield of 970, 893 and 625 kg/ha from plots with 384, 312 and 236 trees/ha compared to 472 kg/ha in normal tree density plot (156 trees/ha). Crescent bunding and coconut husk burial resulted in increased yield by 2-3 times.

Extracts and volatiles of healthy bark and fresh frass was characterized by GCMS for identifying kairomones against cashew stem and root borers (CSRB). Phytosanitation helped in reduction of pest population in CSRB infested plots. A new insecticide imidacloprid exhibited significant residual action against nymphs and adults of tea mosquito bug with higher oviposition deterreny.

Spread prepared from cashew kernel baby bits had a shelf life of six months at $<0^{\circ}\text{C}$ and $6-10^{\circ}\text{C}$. Defatting of cashew kernel baby bits had no effect on the organoleptic acceptability of the spread which could cater the needs of calorie conscious consumers.

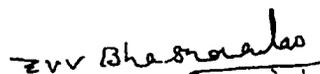
With the financial support of DCCD, Kochi, three cashew gardens were established following high density system of planting in farmers' plots. Non-Governmental Organisations such as KJP foundation, Thiruvananthapuram, SKDRDP, Dharmasthala and Sri Durga Charitable Trust, Keyyur collaborated in organizing Soil and Water/Plant Protection Campaigns in which nearly 500 farmers participated.

I would like to thank my colleagues for pursuing the research projects appropriately and generating data presented in this Annual Report.

I am also grateful to the Editorial Committee for compilation of the achievements of the Centre during the year.

Place : NRCC, Puttur

Date : 31 July 2001



(E.V.V. Bhaskara Rao)

Director



EXECUTIVE SUMMARY

A total of 19 ongoing research projects including four ad-hoc schemes of ICAR, one DBT scheme and one NATP project were in operation at NRCC. Out of these six projects each were under crop improvement and crop management, three projects each were under crop protection and post harvest technology and one project under transfer of technology.

During the planting season, 14 clonal accessions collected from Tamil Nadu (2) and Kerala (12) were planted in NCGB bringing the total number of accessions planted so far to 433. Forty two accessions (1990 planted) were evaluated and characterized as per IPGRI cashew descriptors. Catalogue of minimum descriptors of cashew germplasm accession-III, has been brought out for 102 accessions. A total of 255 accessions have been characterized and catalogued. A segregant of Cuddalore-1 (S 283/3) was found to be dwarf with precocious flowering, cluster bearing habit and small nuts. Under network programme on hybridization in cashew, 65 accessions were chosen based on genetic diversity characters and RAPD data. A total of 191 cross combinations were finalized for crossing programme. Variability in tannins, flavonols, sugars, ascorbic acid and mean cumulative hedonic score of cashew apple juice has been noticed among the accessions screened for identifying the suitable accession for preparation of cashew apple based products.

Callus was induced in leaf segments from in vitro cultures of VRI-2 (low phenol) and H 4-7 (moderate phenol). Root formation was observed in H 4-7 and VRI-2 in leaf cultures on media containing 2,4-D in combination with kinetin. Micropropagated plants were superior to control in growth rate under field condition and showed normal flowering pattern.

Under planting systems and spacing trial yield of 970, 893 and 625 kg/ha was realized from plots with 384, 312 and 236 trees/ha. Pruning resulted in significantly higher yield compared to no pruning in the case of all the treatments except lowest tree density plot (156 trees/ha). Crescent bunding as soil and water conservation structure resulted in doubling the yield. Coconut husk burial in between 2 rows of cashew resulted in increased yield (300%).

In the studies on induction of dwarfing through chemical intervention, soil application of paclobutrazol reduced plant height, canopy spread, length of flowering and non-flowering laterals, and increased number of flowering laterals and nut yield/plant.

Studies on development of integrated pest management of CSRB and TMB were continued. Extracts and volatiles from healthy bark and frass were analysed by GCMS and the compounds identified. Studies on phytosanitation have indicated



the reduced pest population in the CSRB infested plots.

Milk and spread could be prepared from cashew kernel baby bits. Cashew spread could be stored at $< 0^{\circ}\text{C}$ for a period of six months. Cashew kernel oil has got better storage stability than other oils like ground nut, sunflower, and almond. Sweetened and flavoured spread could be prepared from defatted cashew kernel baby bits. Binders such as guar gum, gum acacia and starch did not influence the extent of coating of baby bits. It has been possible to prepare acceptable sweetened, flavoured and coloured cashew kernel baby bits.

Under transfer of technology, three model cashew clonal gardens with high

density system of planting were established during the year, bringing the total number of demonstrations laid out so far to 81. Campaigns on soil and water conservation and plant protection were conducted in collaboration with KJP foundation, Thiruvananthapuram; SKDRDP, Dharmasthala and Sri Durga Charitable Trust, Keyyur in which nearly 500 farmers participated. Besides training programme on vegetative propagation and cashew production technology, a training programme was organized on utilization of cashew apple for farm women in collaboration with KVK of CPCRI, Kasaragod; Regional Centre, CFTRI, Mangalore and Department of Agriculture, Kerala.

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 Vengurla (Maharashtra). Cashew research received further impetus by 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 & 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 Vengurla) were assigned the research component on cashew under AICS&CIP. During the V and VI plan three more centres (Bhubaneswar, Jhargram and Chintamani) came under the fold of AICS& CIP.

Efforts on cashew research were further strengthened by the implementation of World Bank aided Multi State Cashew Project (MSCP) with a 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&CIP, the headquarters of All India Coordinated Research Project on Cashew was shifted to NRC for Cashew, Puttur. A 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 is conceived to undertake mission oriented research projects with the mandate of evolving high yielding varieties of cashew with resistance / tolerance to pests such as tea mosquito, high protein, lysine and other desirable parameters; standardisation of agrotechniques for achieving higher production and productivity with sustainability in view, and transfer of technology to farmers and extension agencies on improved production techniques through training, demonstrations and extension literature.

As Director of National Research Centre



for 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 as under:

- * To conduct mission-oriented research on all aspects of cashew for improving productivity and quality with special reference to export.
- * To serve as a national repository for cashew germplasm and a clearing house for research information on cashew.
- * To act as centre for training in research methodologies and technology updating of cashew and to coordinate national research projects.
- * To provide consultancy regarding cashew production technology.
- * To generate quality planting material.
- * To collaborate with national and international agencies for achieving the mandate.

ORGANIZATIONAL SET UP AND INFRASTRUCTURE

Headquarters

National Research Centre for Cashew is located with its headquarters at Puttur, Dakshina Kannada, Karnataka. The main campus is situated 5 KM away from Puttur town (45° N latitude, 75.4° E longitude and 90 MSL). Out of 69.02 ha of land contemplated for acquisition 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 ha which is 13 KM away from the main campus also forms part of the Research Centre.

The research programmes are pursued in the areas of Crop Improvement, Crop Management, Crop Protection, Post harvest Technology and Transfer of Technology. Besides a well equipped Biotechnology Laboratory, the research centre has sophisticated instruments/facilities for conducting research.

The centre has got well established library in the field of cashew research. It is equipped with 860 books, 775 reprints, Indian and international periodicals (38 & 9) and their back volumes (851), Annual Reports of ICAR and other Institutes. 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, AGRICOL and AGRIS are also available in the library. The library also has library 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 a 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 Chattisgarh which is a non traditional cashew growing area.

Significant achievements of the centre:

- * It has largest germplasm collection of cashew in the country (NCGB) with 433 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.
- * 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 also demonstrated the advantage of growing intercrops like pineapple profitably in cashew gardens.
- * High density planting (625 plant density/ha) was shown to be better than normal spacing (8m x 8m) with an yield increase of 2.5 times that of control.
- * Irrigating cashew at 60-80 litre of water per tree once in four days through drip after initiation of flowering till fruit set and development with the application of 750 : 187.5 : 187.5 g of NPK per tree led to significant higher yields.
- * Leader shoot pruning combined with removal of dead wood has been found to have beneficial effect in cashew.
- * Soft-wood grafting method has been standardised for the commercial multiplication of high yielding varieties cashew.
- * Integrated Pest Management practices for the control of tea mosquito bug and cashew stem and root borer are being worked out. The rearing technique for cashew stem and root borer (CSRB) utilising host bark has been standardised. Volatiles and extracts in hexane from both healthy and frass have been shown to elicit response from adult female beetles of CSRB by EAG studies.
- * Mixing of defatted cashew and soybean flours in the ratio of 1:1 improves the water absorption and emulsification capacity of cashew. Milk and spread could be prepared from cashew kernel baby bits. Acceptable 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.
- * The centre has established very good linkage with farmers and officials of State Departments and Developmental agencies. It conducts training on cashew production technology, vegetative propagation of cashew, and



utilization of cashew apple and holds plant protection/soil and water conservation campaigns and field days for the benefit of farmers.

- * It is serving as an information centre on all aspects of cashew research and development.

Budget

The institute had an annual budget of Rs. 60.0 lakh under plan and Rs.114.50 lakh under non plan for the year 2000-2001. Besides, the research is supported to the tune of 37.44 lakhs through external funding.

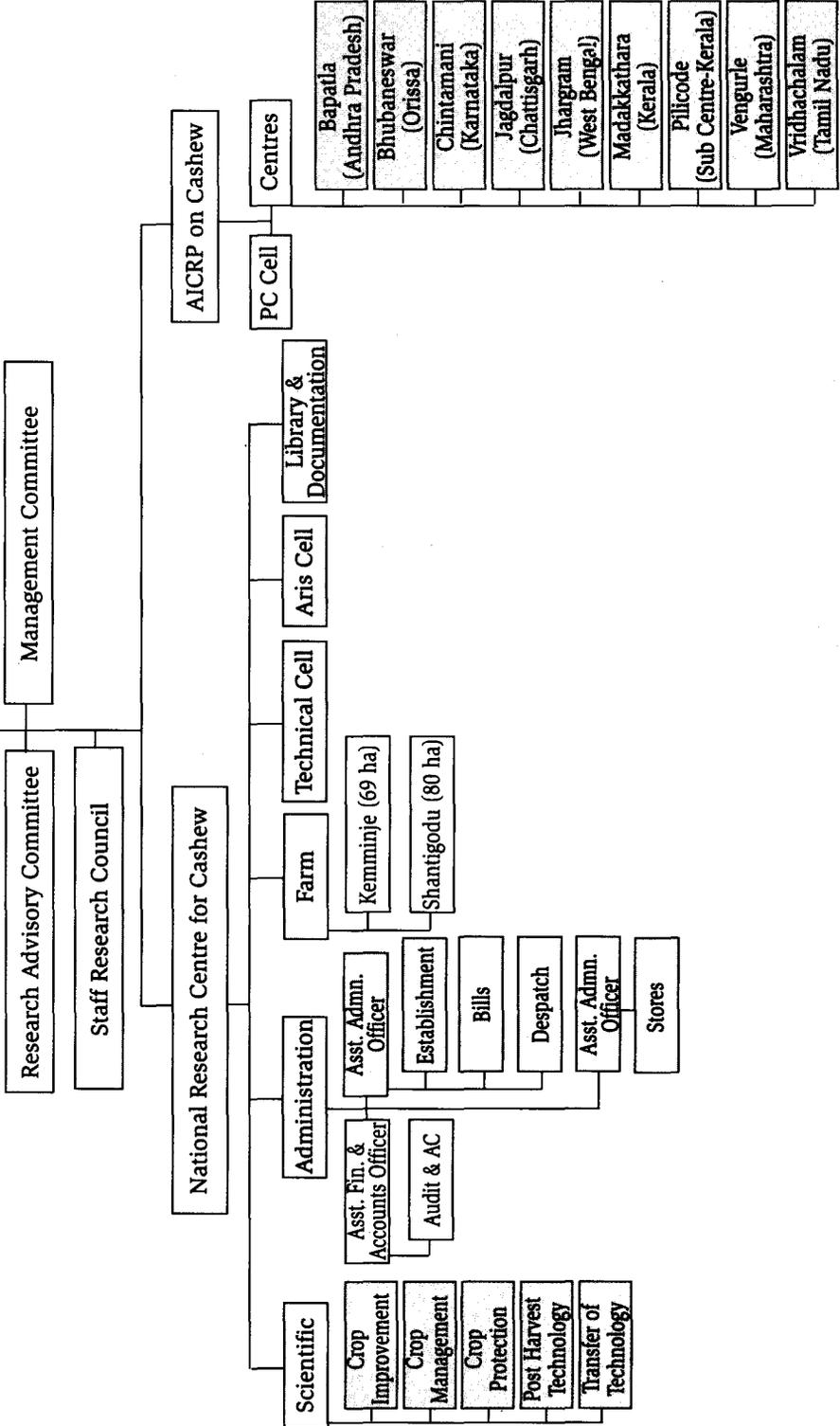
Staff Position as on 31.3.2001

Category	NON PLAN			PLAN			TOTAL		
	Sanctioned	Filled	Vacant	Sanctioned	Filled	Vacant	No. of Posts	No. filled No.	Vacant
Scientific	17	15	2	-	-	-	17	15	2
Technical	22	21	1	4	-	4	26	21	5
Administrative	14	14	-	1	-	1	15	14	1
Supporting	45	43	2	-	-	-	45	43	2
Total	98	93	5	5	-	5	103	93	10

Total Manpower

	Sanctioned	Filled	Vacant
Non Plan	98	93	5
Plan	5	-	5
Total	103	93	10

DIRECTOR



1. CROP IMPROVEMENT

1.1 Genetic resources of cashew

Collection of cashew germplasm - both indigenous and exotic, conservation of germplasm in the National Cashew Gene Bank (NCGB), evaluation and cataloguing of germplasm are being carried out at this research centre.

1.1.1 Germplasm collection and conservation

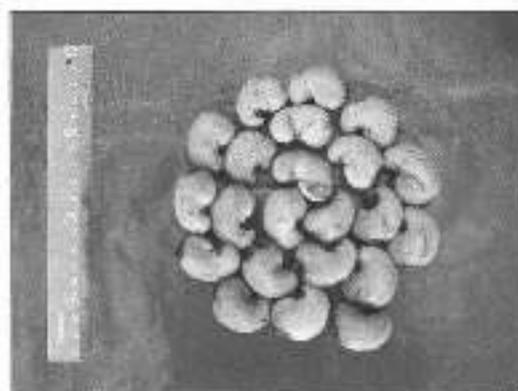
In collaboration with centres of All India Coordinated Research Project on Cashew at Bapatla (Andhra Pradesh) and Vengurle (Maharashtra) 16 high yielding types of cashew were identified from Andhra Pradesh (4) and Maharashtra (12) during April-May 2000. Scions from the

identified trees were collected during August 2000 and the clones have been produced. Scions were also collected from Taliparamba-1 (dwarf type from RARS, Pilicode) and Tree No.2 (Goa Tree No.16 at Shantigodu) and the clones of these have been produced.

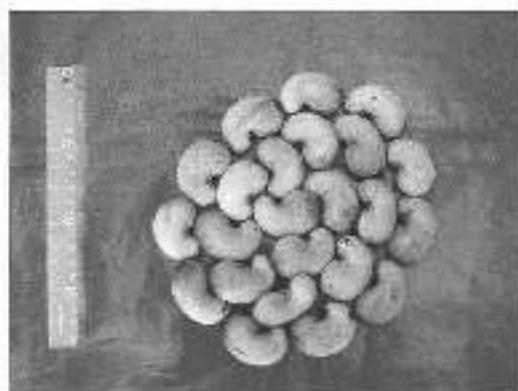
In order to ensure that adequate variability in the germplasm is conserved in NCGB, areas such as Anakkayam (Kerala), Shiroda and Kodar (Goa), Gerukatte and Shedymane (Karnataka) were resurveyed during March 2001 and a total of eight trees were identified for their high yield and medium to bold sized nuts (9-13 g) (Table 1.1).

Table 1.1: Cashew germplasm collection survey undertaken during March 2001.

Areas surveyed	Collection number	Characteristics
Anakkayam Malappuram District Kerala	Anakkayam-1 Anakkayam-2 Anakkayam-3	High yielding, cluster bearing (7-10 nuts/panicle), small to medium sized nuts (6.7 g), high shelling percentage (29-31 %).
Shiroda / Kodar Ponda Taluk North Goa District Goa	Torla-1 Katel Paz-1 Estamol-1	High yielding (8-15 kg), medium to bold sized nuts (7-13 g), big sized apple (50-80 g), high shelling percentage (29-30 %).
Shedymane Kundapur Taluk Udupi District Karnataka	Shedymane-1 Shedymane-2	High yielding (30 kg), bold sized nuts (9 g) and kernels (2.7 g), high shelling percentage (33 %). High yielding (10 kg), bold sized nuts (12.5 g) and kernels (3.5 g), big sized apple (100 g), high shelling percentage (29 %).



Nuts of Shedymane - 1



Nuts of Shedymane - 2

During the year, 14 clonal accessions collected from Tamil Nadu (2) and Kerala (12) were planted in NCGB at Shantigodu, at a spacing of 6m x 6m (6 grafts/accession) bringing the total number of accessions conserved to 433.

Based on genetic diversity, complimentary characters and RAPD data, a total of 65 accessions in NCGB were chosen as parents for hybridization programme under the ad-hoc research scheme (Table 1.2).

1.1.2 Germplasm evaluation

Forty two accessions planted in 1990 were evaluated and characterized after completion of six annual harvests as per

IPGRI cashew descriptors during the year, taking the total number of accessions characterized so far to 255. The "Catalogue of Minimum Descriptors of Cashew Germplasm Accession III", has been published for the 102 accessions [1989 (60) and 1990 (42) planted] which were evaluated and characterized during 1999 and 2000 (Table 1.3).

The cluster analysis was carried out for 255 accessions following K clustering data method using Indostat Statistical Package. These accessions were grouped into 22 clusters. The largest group had 20 accessions and the smallest group had 2 accessions (Table 1.4).

Table 1.2: Cashew accessions from NCGB utilized as parents in the hybridization programme.

Parents	Accessions (NRC)
Female parents (55)	1, 3, 13, 15, 43, 56, 66, 68, 81, 84, 90, 100, 103, 109, 116, 118, 119, 120, 122, 124, 126, 130, 131, 137, 138, 140, 145, 148, 152, 161, 164, 175, 177, 179, 187, 182, 183, 185, 188, 194, 201, 208, 217, 222, 233, 255, 257, 240, 241, 247, 260, 276, 280, 283, 347
Male parents (10)	5 12/29, 5 16/50, 94, 145, 239, 299, 307, 315, 343, 349

Table 1.3: Details of 102 accessions characterized and catalogued during 2000.

Descriptor	Descriptor State	Number of accessions
Tree habit	3. Upright & Compact	6
	5. Upright & Open	94
	7. Spreading	2
Leaf shape	1. Oblong	8
	2. Obovate (Club-Shaped)	66
	3. Oval	28
Branching pattern	1. Extensive	83
	2. Intensive	19
Colour of young leaves	1. Red	8
	2. Yellow Red	76
	3. Green Yellow	18
	4. Purple	1
Season of flowering	3. Early (Nov-Dec)	29
	5. Mid (Dec-Jan)	71
	7. Late (Jan-Feb)	02
Colour of mature apple	1. Yellow	3
	2. Red	90
	3. Yellow Red	9
	4. Red Purple	-
Shape of cashew apple	1. Cylindrical	15
	2. Conical-Obovate	72
	3. Round	12
	4. Pyriform	3
Attachment of nut to cashew apple	3. Loose	21
	5. Intermediate	50
	7. Tight	31
Nut weight	3. Low (< 5 g)	17
	5. Intermediate (5-7 g)	45
	7. High (> 7 g)	40
Weight of cashew apple	3. Low (< 27 g)	3
	5. Medium (27-52 g)	51
	7. High (> 52 g)	48
Flowering duration	3. Short (< 60 days)	25
	5. Medium (60-90 days)	70
	7. Long (> 90 days)	7
Apple to nut ratio	3. Low (< 6.0)	20
	5. Medium (6.0-12.0)	76
	7. High (> 12.0)	6
Shelling percentage	3. Low (< 18.0%)	3
	5. Intermediate (18.0-28.0%)	36
	7. High (> 28.0)	63

Table 1.3: Details of 102 accessions characterized and catalogued during 2000. (Contd.)

Descriptor	Descriptor State	Number of accessions
Kernel weight	3. Low (<1.2 g)	7
	5. Intermediate (1.2-2.5 g)	82
	7. High (>2.5 g)	13
Shell thickness	3. Thin (<2.5 mm)	17
	5. Intermediate (2.5-4.0 mm)	75
	7. Thick (>4.0 mm)	10
Attachment of testa to kernel	3. Loose	86
	7. Tight	16
Cumulative yield per plant (six annual harvests)	3. Low (<9 kg)	76
	5. Medium (9-19 kg)	26
	7. High (>18 kg)	-

Table 1.4: Grouping of 255 accessions into clusters based on K-clustering method.

Cluster number	No. of accessions	Accessions in the cluster
1	18	37, 91, 103, 106, 137, 142, 143, 147, 149, 150, 151, 171, 175, 191, 193, 195, 196, 206
2	9	190, 214, 215, 220, 221, 222, 240, 247, 252
3	5	174, 176, 194, 207, 255
4	10	64, 99, 126, 162, 184, 187, 192, 200, 201, 243
5	11	62, 63, 65, 67, 68, 69, 71, 77, 80, 84, 85
6	13	9, 13, 18, 27, 28, 29, 30, 32, 41, 42, 45, 54, 78
7	15	216, 218, 219, 223, 226, 228, 229, 230, 231, 232, 233, 234, 235, 246, 248
8	7	59, 87, 93, 115, 140, 145, 164
9	14	2, 4, 5, 7, 8, 11, 12, 19, 20, 21, 22, 38, 46, 76
10	18	14, 15, 16, 17, 23, 34, 44, 48, 51, 52, 53, 55, 57, 61, 70, 74, 89, 98
11	18	79, 81, 83, 86, 168, 185, 188, 197, 198, 199, 202, 208, 210, 213, 245, 249, 251, 253
12	7	155, 156, 161, 166, 172, 173, 204
13	10	99, 100, 101, 109, 119, 122, 133, 141, 146, 212
14	8	224, 225, 227, 236, 237, 238, 239, 250
15	12	66, 107, 111, 112, 154, 160, 170, 178, 180, 183, 189, 211
16	17	93, 94, 102, 108, 110, 113, 114, 117, 118, 120, 121, 128, 129, 130, 131, 135, 148
17	5	177, 203, 205, 217, 244
18	13	92, 95, 96, 97, 105, 116, 127, 132, 134, 136, 138, 139, 144
19	7	1, 3, 6, 39, 40, 47, 56
20	20	58, 104, 123, 124, 125, 157, 158, 159, 163, 165, 167, 169, 179, 181, 182, 186, 209, 241, 242, 254
21	16	10, 24, 25, 26, 31, 33, 35, 36, 43, 49, 50, 60, 72, 73, 75, 82
22	2	152, 153

Nine accessions of seedling origin planted in NCGB during 1997 were evaluated for their growth. These accessions were collected from Brazil (5), Mozambique (1), Tamil Nadu (1), and Karnataka (2). Mean plant height after 3¹/₂ years of planting was minimum in Kodippady-2 (1.10 m), followed by Cuddalore-1 (1.81 m) and Nampula 11-7 (1.96 m) and the plant height was maximum in CCP 76 (3.53 m), followed by CCP 06 (2.97 m), CCP 1001 (2.93 m), CCP 96 (2.63 m) and CCP 09 (2.24 m). A segregant of Cuddalore-1 (S 28/3) was found to be dwarf (1.5 m height) having precocious flowering, cluster bearing habit with small sized nuts. Kodippady-2 (S 29/1, S 29/2) and Cuddalore-1 (S 28/3) could be ideal parents for transferring dwarf trait to vigorous growing high yielding types.

In order to identify suitable accessions for the preparation of cashew apple juice based products, juice from different accessions in NCGB was characterized for tannins, flavonols, sugars and ascorbic acid contents. Clarified cashew apple juice was evaluated for colour, flavour, taste and astringency by a panel of 15 judges. A total of 36 accessions have been analysed for the above constituents. Among the accessions tannin content varied from 1.20 to 9.45 mg/ml. Flavonol content showed variation between 0.038 and 1.002 mg/ml. Sugar content among the accessions varied from 4.73 to 107.70 mg/ml. Ascorbic acid content exhibited variation from 1.79 to 5.77 mg/ml. Fourteen accessions have low tannin (< 3.00 mg/ml), 16 have low flavonols (< 0.030 mg/ml), seven have high sugars (> 70.00 mg/ml) and seven have high ascorbic acid (> 4.00 mg/ml). The accession, NRC 59, has all the desirable characters such as low tannin

and flavonols and high sugars and ascorbic acid contents for the preparation of cashew apple juice based products. Based on the results, accessions with desirable characters such as low tannin, high sugar, high ascorbic acid content with mean cumulative hedonic score of 13 to 17 have been identified (Table 1.5 and 1.6).

DNA finger printing of cashew germplasm is being carried out in collaboration with Division of Horticulture, UAS, Bangalore under DST funded project. Leaf samples of 153 accessions (NRC 1 - 153) of cashew were supplied from NCGB during 1999. RAPD markers generated by seven selected operon primers (10 base-long) which produced 123 consistent, unambiguous, repeatable bands ranging from 400 bp to 3 Kbp were used to assess the diversity among 90 accessions. The analysis of the results (Squared Euclidean distance, Ward's clustering) revealed that the diversity in Indian cashew germplasm is moderate and not narrow as reported earlier.

In order to identify the germplasm collection and to avoid duplication, 392 accessions conserved at NCGB at Puttur, have been assigned collection numbers (IC nos.) by NBPGR, New Delhi. Attempts are underway to get the IC nos. for the remaining accessions (757) maintained at NRC Puttur and Regional Cashew Gene Banks at different AICRP on Cashew Centres.

1.2 Varietal improvement of cashew

Genetic improvement of cashew for yield and other important characters such as nut weight (> 7g), kernel weight (> 2g), shelling percentage (> 28%) and quality of

Table 1.5: Grouping of accessions (36) based on biochemical composition of cashew apple juice.

Range (mg/ml of juice)	No. of accessions	Accessions (NRC)
Tannin (1.20 - 9.45)		
< 3.00	14	9, 56, 59, 66, 79, 80, 81, 84, 100, 112, 127, 228, 236, 247
3.10 - 6.00	15	3, 35, 43, 107, 109, 111, 130, 133, 175, 176, 217, 218, 233, 241, 159
6.10 - 9.00	4	18, 72, 120, 43, 160
> 9.00	3	13, 140, 279
Flavonols (0.038 - 1.002)		
< 0.030	16	9, 18, 59, 66, 79, 80, 81, 84, 100, 107, 112, 160, 175, 233, 43, 247
0.031 - 0.060	16	3, 35, 56, 109, 111, 120, 127, 130, 133, 159, 176, 217, 218, 228, 236, 241
0.061 - 0.090	3	13, 72, 140
> 0.091	1	279
Sugars (4.73 - 107.70)		
< 35.00	16	13, 18, 66, 80, 100, 107, 111, 112, 120, 160, 175, 176, 233, 236, 43, 247
35.10 -70.00	13	3, 56, 72, 81, 84, 127, 130, 133, 140, 159, 217, 228, 279
> 70.00	7	9, 35, 59, 79, 109, 218, 241
Ascorbic acid (1.79 - 5.77)		
< 2.00	4	79, 81, 100, 279
2.01 - 4.00	25	3, 9, 13, 18, 56, 66, 72, 80, 84, 107, 109, 111, 120, 127, 130, 133, 140, 159, 160, 176, 228, 233, 236, 241, 247
> 4.00	7	35, 59, 112, 175, 217, 218, 43

kernels was attempted. One thousand hybrids from 75 cross combinations and 60 elite genotypes/varieties and selfs were evaluated for various important characters. A total of 800 hybrids made from 76 cross combinations were field planted during the year.

1.2.1 Evaluation of recommended varieties

Ten recommended varieties in first trial and nine varieties in second trial were

evaluated with VRI-2 as common check. The performance of BPP-4 was better than the remaining nine varieties in the first trial for the mean cumulative yield for the last four years (8th to 11th harvest) with 2.25 kg nut yield per tree per year (Table 1.7). In the first trial, several individual cashew trees have been found with yield potential of more than 1 t/ha in 9 out of 10 released varieties. In the second trial, the highest mean cumulative

Table 1.6: Accessions with desirable characters.

Desirable characters	Accession nos.
Low tannin (1 to 3 mg/ml)	56, 66, 127, 228, 59, 9, 236, 100, 112, 84, 80, 79, 81
High sugar (70-100 mg/ml)	79, 241, 59, 9, 109, 35, 218
High ascorbic acid (2 to 5 mg/ml)	127, 130, 228, 3, 84, 241, 56, 160, 59, 43, 159, 66, 85, 18, 233, 236, 13, 247, 35, 72, 133, 140, 9, 109, 111, 176, 217, 112
MCH of 13 to 17	3, 79, 81, 127, 236, 43, 133, 228, 59, 35, 109, 241, 176, 80, 233, 72, 218, 112
Low tannin and high ascorbic acid	56, 66, 127, 236, 84
Low tannin, high ascorbic acid and MCH of 13 to 17	228, 112, 80, 79
Low tannin, low flavonols, high sugar and ascorbic acid, MCH of 13 to 17	59
Low flavonols (0.01 to 0.3 mg/ml)	56, 66, 247, 79, 81, 100, 102, 18, 233, 175, 59, 9, 84, 80, 160, 43, 107
Low tannin and MCH of 13 to 17	81
High sugar and MCH of 13 to 17	218
High sugar and ascorbic acid, MCH of 13 to 17	109, 35
High ascorbic acid and MCH of 13 to 17	3, 241, 43, 233, 72, 133, 176

yield (1.33 kg/tree/year) for the last four years (3rd to 6th harvest) was recorded in K-22-1 (Table 1.7). In this trial also, varieties such as K-22-1, BPP-3 and Vengurla-4 had individual cashew trees with yield potential of more than 1 t/ha. Regarding the flowering phase, mixed flowering phase was observed in all the 20 varieties studied and in most of the varieties mixed phase was of longer duration than that of male phase except in Ullal-1, NDR-2-1 and K-22-1. Number of hermaphrodite flowers produced per panicle was more than 40 in six varieties (BPP-1, BPP-2, VRI-2, BPP-3, Ullal-2 and NRCC Sel-1) (Table 1.7). Sex ratio

(hermaphrodite : staminate flowers) and percentage of hermaphrodite flowers varied from 0.025 to 0.313 and from 2.4% to 23.9% respectively among the varieties studied (Table 1.7).

The correlation and regression analysis showed that number of flowering laterals, fruiting intensity and yield per square metre of canopy are important yield component characters. Both fruiting intensity and yield per square metre of canopy had high positive correlation with estimated yield per tree (+0.868 and +0.870 respectively) (Table 1.8).

Table 1.7: Performance of recommended varieties for yield and flowering characters.

Variety	Mean yield (kg/tree/year) (8th-11th harvest)	Hermaphrodite flower		Sex ratio (Herm: Staminate)	Flowering phase (in days)		Duration of mixed phase (%)
		Absolute number/panicle	% of total flowers		Male Phase	Mixed phase	
Trial-1							
BPP-1	1.78	41.5	17.5	0.212	2	48	96.0
BPP-2	1.95	42.3	16.1	0.192	2	42	95.5
BPP-4	2.25	23.2	14.6	0.171	0	36	100.0
BPP-5	2.07	15.7	9.1	0.100	6	41	87.2
BPP-6	2.01	12.0	7.3	0.079	13	23	63.9
BLA 139-1	1.63	10.7	5.6	0.059	13	28	68.3
BLA 39-4	1.90	25.8	5.2	0.054	11	49	81.7
Ullal-1	1.49	14.7	2.4	0.025	47	26	35.6
VRI-1	1.48	18.7	8.3	0.090	20	24	54.5
VRI-2	2.13	56.5	23.9	0.313	0	44	100.0
Trial-2*							
BPP-3	0.75	47.7	12.7	0.146	10	40	80.0
K-22-1	1.33	13.0	3.7	0.038	32	16	33.3
NDR-2-1	1.20	17.0	5.2	0.055	31	15	32.6
Vengurla-1	1.03	29.3	8.8	0.096	7	42	85.7
Vengurla-4	0.94	29.5	10.7	0.119	10	31	75.6
Ullal-2	1.12	42.5	8.8	0.096	25	32	56.1
NRCC Sel-1	0.76	54.2	12.1	0.138	18	52	74.3
NRCC Sel-2	0.76	20.0	6.9	0.074	13	28	68.3
VRI-2	1.04	22.7	9.0	0.099	11	32	74.4

* In trial 2, the mean yield is for 3rd to 6th harvest

Table 1.8: Correlation and regression coefficients of flowering and fruiting characters (X) with estimated yield (Y) in 20 varieties of cashew.

Characters (X)	Correlation coefficient (r) of characters with estimated yield/tree	Regression coefficient (b) of estimated yield per tree (Y) on independent characters (X)
Number of flowering laterals	0.494	0.409
Flowering lateral intensity	0.186	0.020
Fruiting intensity	0.868	0.469
Yield per sq. metre of canopy	0.870	0.075



Regression coefficient of estimated yield per tree on number of flowering laterals and fruiting intensity was on higher side (+0.409 and +0.469 respectively) (Table 1.8). Analysis was also done based on mean of three years data (1997-98 to 1999-2000) and the trend of correlation and regression between estimated yield and flowering / fruiting characters is similar to that observed for the current year.

1.2.2 Pollen germination studies

Pollen germination (*in vitro*) using pollen grains from staminate and hermaphrodite flowers of 35 released varieties was studied. Varieties differed for pollen germination capacity. Pollen grains from staminate flowers were found to have higher germination as compared to those from hermaphrodite flowers. Pollen germination was higher in varieties BPP-2 (45.41%), VRI-1 (44.74%) and BLA 39-4 (43.73%) when staminate flowers were used as pollen source. When hermaphrodite flowers were used as pollen source, the highest pollen germination was observed in varieties Dhana (32.04%), Kanaka (28.68%) and

VRI-3 (25.48%). These studies have indicated that longer period of mixed phase would be ideal wherein adequate pollen from staminate flowers and also sufficient number of hermaphrodite flowers are available for increased fruit set.

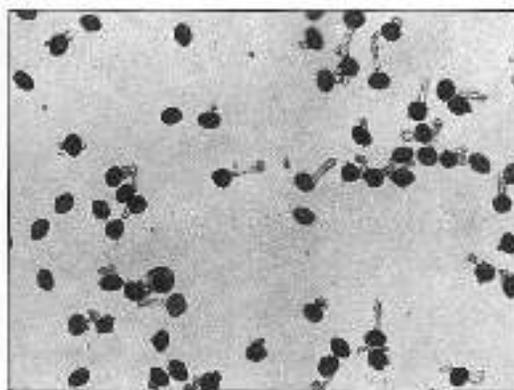
1.2.3 Status of adherence of testa to the kernel

Thirty four varieties were evaluated for status of adherence of testa to the kernel by recording the number of strokes of knife required for removal of testa in order to identify varieties with loose testa which is a desirable character in cashew processing resulting in saving on labour cost and also in lesser damage to the kernel. The varieties evaluated differed for this character and they were classified into three categories, namely loose (< 5.0 strokes), medium (5.0 - 7.5 strokes) and tight (> 7.5 strokes). Out the 34 varieties, NRCC Sel-1, Vengurla-1 and Ullal-4 had loose adherence. Nineteen varieties had medium adherence while the remaining 12 had tight adherence of testa (Table 1.9).

1.2.4 Biochemical and organoleptic evaluation of released varieties

i) Cashew kernels:

Cashew kernels from 32 released varieties have been characterized for oil, protein, sugar and starch contents. Similarly, kernels have been assessed by a panel of judges for colour, size, texture and taste. The oil content among the varieties tested varied from 34.7% (NDR-2-1) to 48.4% (Kanaka). Proteins, sugar and starch content were analysed on defatted kernel flour. The range for protein content was from 35.6%



In vitro pollen germination of cashew

Table 1.9: Status of adherence of testa to kernels in different cashew varieties.

Status of adherence	Mean no. of strokes required	No. of varieties	Name of varieties
Loose	< 5.0 strokes	3	Vengurla-1, NRCC Sel-1, Ullal-4
Medium	5.0 - 7.5 strokes	19	BLA 39-4, BLA-139-1, K-22-1, Kanaka, BPP-1, BPP-2, BPP-3, BPP-4, BPP-5, BPP-6, VRI-1, VRI-2, Ullal-1, Ullal-2, Vengurla-3, Vengurla-4, Vengurla-5, NRCC Sel-2, Chintamani-1
Tight	> 7.5 strokes	12	NDR-2-1, Dhana, Priyanka, Amrutha, Vengurla-2, Vengurla-6, Vengurla-7, VRI-3, Goa-1, Ullal-3, UN-50, BPP-8

(NDR-2-1) to 65.82% (BPP-6). Sugar content showed variation between 6.98% (VRI-1) and 20.62% (Vengurla-6). Starch content exhibited variation among different varieties from 14.5% (Jhargram-1) to 28.3% (NDR-2-1). Results obtained indicated that composition of kernels for oil, protein, sugar and starch and also kernel size did not influence the acceptability. Among the released varieties evaluated, Selection-1 was the most preferred with mean cumulative hedonic (MCH) score of 7.1 while BPP-3 and BLA-139-1 were the least preferred with MCH score of 18.7 (Table 1.10).

ii) Cashew apples:

In order to identify suitable varieties for the development of cashew apple juice based products, cashew apple juice from 26 released varieties of cashew was analysed for tannins, flavonols, sugars and ascorbic acid. Clarified cashew apple juice from the different varieties was also evaluated for colour, flavour, taste and astringency by a panel of judges. Tannin content in juice varied from 0.81 to 7.49 mg/

ml while flavonol showed variation between 0.087 and 0.647 mg/ml. The range for sugar content in juice was from 6.56 to 96.18 mg/ml. Ascorbic acid content showed variation from 1.25 to 5.11 mg/ml. Mean cumulative hedonic (MCH) score for colour, flavour, taste and astringency varied from 14.0 to 19.28. Among the varieties tested, cashew apple juice from nine varieties had low tannin (1 to 3 mg/ml), six varieties had higher sugar (70 to 100 mg/ml), 18 varieties had high ascorbic acid content (2 to 5 mg/ml) and 12 varieties exhibited MCH score ranging between 13 and 17 (Table 1.11).

1.2.5 Evaluation of hybrids/selfs

Two promising hybrids, namely, H-46 (BPP-6 x A 18/4) and H 32/4 (BPP-5 x VRI-1) are under field evaluation at Karnataka Cashew Development Corporation, Puttur division. H 32/4 is under evaluation in some selected farmers' fields also. A self S-15/14 is under testing along with six hybrids and three controls in a replicated trial. Highest annual yield of 3.44 kg/tree in 5th harvest and highest

Table 1.10: 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
Ullal-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

cumulative yield of 8.0 kg/tree for five harvests were recorded in S-15/14 self as compared to 2.26 kg/tree and 4.61 kg/tree, respectively in VRI-2 variety.

1.2.6 Improvement of nut size in released varieties

A total of 1000 hybrids from 75 cross

combinations are under evaluation. Hybrid H-1250 (VRI-2 x Sel-2) and H-1354 (V-5 x VTH 711/4) performed better for cumulative yield for six harvests (9.55 kg/tree and 11.35 kg/tree respectively). H-1250 had annual yield of 3.4 kg/tree and with nut weight of 7.7 g, kernel weight of 2.22 g and shelling percentage of 28.9%.

Table 1.11: Varieties with desirable characters for cashew apple juice.

Low tannin (1 to 3 mg/ml)	VRI-2, Bhubaneswar-1, BPP-1, Jhargram-1, VRI-3, BPP-8, Goa-1, BPP-4, BLA 39-4
High sugar (70-100 mg/ml)	BPP-4, Bhubaneswar-1, BPP-8, VRI-3, BLA 39-4, Jhargram-1
High ascorbic acid (2 to 5 mg/ml)	BPP-4, VRI-3, Bhubaneswar-1, BPP-5, BPP-1, Goa-1, BPP-3, Kanaka, VRI-1, V-6, Sel-1, V-3, BPP-6, V-4, Ullal-3, Ullal-4, Ullal-2, NDR-2-1, K22-1, Jhargram-1, Sel-2, Bla 139-1
MCH range of 13 to 17	Sel-1, Jhargram-1, VRI-1, BPP-4, BPP-8, BPP-1, V-3, K-22-1, V-6, Goa-1, Ullal-2, V-1, Bla 139-1
Low tannin, high sugar, high ascorbic acid and MCH of 13 to 17	BPP-4, Jhargram-1
Low tannin, high sugar and ascorbic acid	Bhubaneswar-1, VRI-3
Low tannin, high ascorbic acid and MCH of 13 to 17	Sel-1, Goa-1
Low tannin, high sugar and MCH of 13 to 17	BPP-8
Low tannin and high ascorbic acid	BPP-1
Low tannin and high sugar	BLA 39-4
High ascorbic acid and MCH of 13 to 17	VRI-1, V-6, V-3, Ullal-2

MCH (Mean Cumulative Hedonic Score)

1.3 Micropropagation

1.3.1 Callus induction from leaves

Callus was induced on leaf segments excised from *in vitro* cultures of varieties with low phenol (VRI-2) and moderate phenol (VTH 174) content on MS media containing half major nutrients, 6% sucrose, cysteine HCl (100 mg/l), glutamine (400 mg/l) and 2,4-D (2-8 µM) alone and in combination with NAA and kinetin (Kin). In all the media used for callus induction, VRI-2 performed better than VTH 174 in callus induction. The callus was

initially white and turned black and was slow growing. For moderate callus formation in VTH-174, half MS media with combination of 2,4-D (4 µM) and Kin (4 µM) was the best and for callus formation in VRI-2 2,4-D (4 µM) alone was sufficient. Root formation was observed in VTH-174 and VRI-2 leaf cultures on medium with 2,4-D (4 µM) and NAA (4 µM) or Kin (2 µM), indicating the regenerative potential of the tissue. In the media of Sondahl and Sharp (1977) containing 2,4-D (5 µM) or Kin (20 µM) profuse callus formation was observed from VRI-2 and H-4-7 leaf cultures

with root formation in the dark except that root formation was slow in VRI-2 cultures. In the media with 2-4-D (4 μ M) and Kin (12 μ M) globular structures appeared on the leaf callus in one of the cultures.

1.3.2 Callus induction from nucellus

Nucellus culture was attempted for somatic embryogenesis using four varieties VRI-2, H-4-7, NRCC Sel-1 and Ullal-3 using eight media combinations and a control (hormone free). Bisected ovules and nucellar tissue excised from 2-3 week old nuts of VRI-2 were initiated into culture in dark on MS medium containing half major nutrients, 6% sucrose, 400 mg/l glutamine, 100 mg/l cysteine HCl and 2,4-D (2-8 μ M) alone and in combination with NAA, BAP, Kinetin. Callus formation was observed from nucellus on cultures with concave side up within one week whereas, no callus formation was observed when bisected ovules were placed with convex side up. Callus induction was observed in all the media including control. But the mean callus growth varied with media and variety. Sampling of nut at various stages indicated that 3-5 week old immature nuts as best for getting maximum callus growth from nucellus. Callus was not formed on medium devoid of sucrose. Callus growth increased with increased sucrose concentration. Nucellus callus induced last year and maintained on hormone free medium in light were sub-cultured, on MS medium containing BAP, Kin, 2ip, zeatin (0.5, 2.0 mg/l each), ABA (2.5 mg/l) and GA3 (0.5 mg/l) alone with a common supplement of NAA (0.1 mg/l). Although callii showed fasciated leaf structures and cotyledonary structures there was no complete

differentiation. On 2 mg/l kinetin one of the cultures differentiated into plant like structures with prominent root formation.

1.3.3 Evaluation of micropropagated plants in the field.

In the replicated trial planted in 1999 with micropropagated and grafted plants of two varieties viz., H-4-7 and VRI-2 in CRD with 5 replications and 4 plants per plot observations on growth parameters (girth and height) and flowering and fruiting were recorded. In the first year after planting, micropropagated plants of H-4-7 had more height and girth than their control plants (grafts). Normal flowering was observed in all the micropropagated plants planted in 1997 and fruiting was observed in all the three plants of BLA 39-4. Dwarf genotype did not show fruit setting.

1.3.4 Micropropagation from shoot explants of grafts (DBT programme)

Under DBT, work on standardisation of micropropagation and micrografting were initiated. Shoot cultures from field grown trees (14 year old) and young cashew grafts (1-2 year old) were initiated on Murashige and Skoog (1962) (MS) medium containing half strength major nutrients, 3% sucrose, 0.2% activated charcoal gelled with 2.25 g/l phytigel. Culture response depended on season and type of explants. Contamination varied from 7.1 - 100% and it was least during April. Bud break varied from 13.6 - 55.4% with maximum being in April. Generally dry months were favourable for higher bud break and lower contamination. Nodal cuttings regenerated better and had higher percentage of bud break (39.6%) than

shoot-tips (92.9%). Similarly explants of repetitive grafts showed higher per cent bud break (75%) than their original grafts. Spraying with 100 mg/l BAP and 50 mg/l GA₃ on stock plants 8-10 day prior to collection had no significant effect on explant response. Pre-soaking treatment of shoots in BAP (5-10 mg/l) for a brief period however, showed improvement in bud break (33.3%) of explants from field trees.

Three gelling agents namely agar (0.7%), agargel (3.7 g/l), phytigel (2.25 g/l) were tested along with liquid (control) in MS basal medium. Gelling agents had significant effect on bud break with low bud break (19%) in liquid medium. Sucrose and glucose at equimolar concentrations (29.4, 58.8, 82.2, 117.6, 186.4 mM) showed significant influence on explant response. Bud break was not observed in the absence of sugars in the medium. Budding response was restored when explants from sucrose free medium were transferred to sucrose medium. Long shoots of 4-6 months old showed axillary shoot bud proliferation (1-11 shoot buds/explant) on MS medium containing either thidiazuron (TDZ) or in combination of TDZ with BAP. TDZ (0.1 mg/l) induced maximum number of shoot buds per culture (3-5 buds/explant). Culture of multiple shoots on GA₃ (0.5 to 5 mg/l) resulted in abscission of leaves and callus at petiole junction but there was no appreciable elongation of shoot buds. Similarly, microshoots cultured on half-MS liquid medium containing NAA, IBA (2.5 and 10 µM) alone and their combination of NAA + IBA (2.5 µM each), NAA + IBA (2.5 µM each) + phloroglucinol (1 µM) showed no rooting. MS medium containing paclobutrazol

(0.5) induced rooting (75%) in seedling explants after 4-5 months.



Axillary shoot bud proliferation in nodal cultures of mature tree

1.3.5 Micrografting

Root stock seedlings, for micrografting were raised *in vitro* by sterilizing mature seeds and culturing on absorbent cotton or soilrite medium. Germinated seedling of 20-25 day old were used as rootstock after decapitation. Scions for micrografting were prepared from the *in vitro* shoot cultures (3-5 week old) established from mature tree source (grafts). Seedlings emerged at different time intervals (3, 6, 9, 12, 15 days) from cotton medium were used as rootstock for micrografting (hypocotyls grafting) using uniform scions from *in vitro* shoot cultures. Seedlings emerged after 3-6 days resulted in higher graft success (42.8 - 75%). Effect of pre-treatment of scion was tested by pre-soaking *in vitro* shoot cultures (scion shoot) in



different solutions viz., (i) 6-benzylaminopurine (BAP 10 ppm), (ii) DIECA (2 g/l), (iii) Ascorbic acid (0.01 %) and (iv) sterile distilled water for a brief period (5 min) and micrografted following the hypocotyls grafting method. Among the different pre-treatments tried, DIECA treated scion gave the highest per cent graft success (45%). In the limited number of grafts made ($n = 44$) using uniform root stock seedlings and scion and following both hypocotyls and epicotyl method of grafting, maximum grafting success (44.4%) was observed in hypocotyls method

as compared to that observed in epicotyl method of grafting (24%).

Micrograft culture established was tried by culturing hypocotyls grafts on both solid and liquid MS medium containing half strength major nutrients and 2 levels of sucrose (3 and 6%) and the number of grafts successful in each were computed. Maximum grafts success (75%) was observed on 6% liquid medium. Micrografts made using (*in vitro* cultures) scions of mature tree were successful and established in pots.

2. CROP MANAGEMENT

2.1 Planting systems and spacings

The study was initiated to understand growth behaviour 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 sub plot treatments having pruning and no pruning.

During December soil moisture at deeper levels (18.34 to 23.70%) was within

available range (16.33 to 32.0%) in plot with 400 (5 m x 5 m) and 500 trees (5 m x 4 m)/ha. Whereas, during March, the moisture level dropped (15.02 to 15.12%) below available range giving an indication that there existed competition in high tree density plots (400 and 500 trees/ha) for moisture. In low tree density plots the moisture levels at lower depths did not change both in December and March indicating that there was no competition for moisture at deeper depths (Table 2.1).

The tree height increased significantly (4.95 m) in high tree density plot (500 trees/ha) over low tree density plot (4.13 m - 156 trees/ha). The tree density had no effect on girth of stem. Effective canopy height was

Table 2.1: Effect of tree density on mean moisture content (%) at three depths.

Spacing (m)	Density Nos/ha	0-30 cm		30-60 cm		60-90 cm		Mean for all the depths	
		Dec	Mar	Dec	Mar	Dec	Mar	Dec	Mar
5 x 5	400	17.37	15.67	19.42	17.61	18.34	15.02	18.37	16.10
6.5 x 6.5	236	16.40	15.22	22.46	19.48	19.71	16.76	19.51	17.15
8 x 8	156	13.52	12.31	19.49	18.20	23.70	21.14	18.90	17.21
5 x 4	500	17.47	15.84	19.73	16.97	19.52	15.12	18.89	15.97
6.5 x 4	384	16.89	15.94	18.18	17.15	19.44	16.60	18.09	16.56
8 x 4	312	17.86	15.44	19.50	17.19	18.28	15.44	18.60	16.15
Mean		16.58	15.14	19.81	17.77	19.79	16.68	18.73	16.52
	CD (0.05) for density			:	0.58				
	CD (0.05) for seasons			:	0.495				
	CD (0.05) for depth			:	0.60				
	CD (0.05) for density and depth			:	1.34				
	CD (0.05) for season and depth			:	0.85				

Table 2.2: Effect of tree density on girth of stem, tree height, canopy height, canopy spread (NS & EW) and ground coverage.

Spacing (m)	Density (Nos/ha)	Stem girth (cm)			Tree height (m)			Canopy height (m)			Canopy spread (N-S) (m)			Canopy spread (E-W) (m)			Ground coverage (%)		
		A	B	Mean	A	B	Mean	A	B	Mean	A	B	Mean	A	B	Mean	A	B	Mean
5 x 5	400	65	63.00	64.00	5.00	4.20	4.95	1.16	1.08	1.12	6.2	5.34	5.27	5.04	5.93	5.49	82.00	99.90	90.95
6.5 x 6.5	236	55	54.66	54.83	4.00	3.80	3.90	1.25	1.16	1.21	5.6	6.20	5.90	5.88	5.56	5.72	60.79	63.95	62.37
8 x 8	156	49	53.16	49.58	3.50	4.76	4.13	1.88	1.74	1.81	7.2	7.20	7.20	6.16	6.56	6.36	54.78	57.99	56.38
5 x 4	500	54	63.00	58.50	4.98	4.95	4.84	0.91	0.87	0.89	4.0	4.75	4.37	6.08	5.33	5.71	100.0	99.85	99.92
6.5 x 4	384	56	62.50	59.25	4.51	4.95	4.73	1.00	1.03	1.01	4.5	4.00	4.25	5.86	6.92	6.39	83.17	89.94	86.55
8 x 4	312	52	52.00	52.00	4.51	3.50	4.00	1.16	1.12	1.14	4.2	3.80	4.10	6.92	7.48	7.20	76.15	77.98	77.06
CD (0.05)																			
density			5.38			0.67				0.34			0.40			0.76			
CD (0.05)																			
pruning																			

A - Pruned, B - Unpruned

significantly more in low tree density plots (156, 236, 384 and 312 trees/ha) than high tree density plots.

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 (99.92% in 500 trees/ha plot and 90.95% in 400 trees/ha plot) (Table 2.2).

Light interception was significantly higher in high tree density plot (83.78 and

97.25% in plot with 400 and 500 trees/ha) than low tree density plots (44.69 to 47.65% in 156 trees/ha plot, 64.84 to 74.07 in 236 trees/ha plot and 69.12 to 76.51 in 312 trees/ha plot) (Table 2.3).

Highest sun exposed canopy area was in plots having tree density of 384/ha (9303 m²/ha) followed by plots with 312 trees/ha (7525 m²/ha) and 236 trees/ha (6454 m²/ha). The sun exposed canopy area was the lowest in high tree density plot (2650 m²/ha in 400 trees/ha plots, 2717 m²/ha and 500 trees/ha).

Table 2.3: Light interception by canopy (%).

Spacing (m)	Density (Nos/ha)	Pruned	Unpruned	Mean
5 x 5	400	82.78	91.13	86.95
6.5 x 6.5	236	74.07	64.84	69.45
8 x 8	156	44.09	47.65	45.92
5 x 4	500	88.65	97.25	92.07
6.5 x 4	384	69.12	76.51	72.81
8 x 4	312	69.12	76.51	72.82
Mean		71.30	75.37	
CD for density				3.75
CD for pruning				3.50

Table 2.4: Shade induced dry branches and leaves produced (t/ha).

Spacing (m)	Density (Nos/ha)	Branches	Leaves
5 x 5	400	1.98	0.74
6.5 x 6.5	236	0.88	0.35
8 x 8	156	0.20	0.10
5 x 4	500	2.86	0.87
6.5 x 4	384	1.76	0.74
8 x 4	312	1.20	0.50
CD for density		0.43	0.17

It was in the medium range in plot with 156 trees/ha (4575 m²/ha). In high tree density plots (400 and 500 trees/ha) shade induced weak branches as well as moisture stress induced dry branches were more (1.98 to 2.86 t/ha) than those plots with 384 (1.76 t/ha), 312 (1.2 t/ha) and 236 trees/ha (0.88 t/ha). This was mainly due to overlapping of branches resulting in shading of the canopy area as well as drying of branches. In high tree density plots the sun exposed canopy area was minimum as a result of mutual shading of branches (Table 2.4).

Annual total cashew leaf deposit collected at the base of the plant was 2.34 and 2.80 t/ha in high tree density plots (400 and 500 trees/ha). Next highest leaf deposit was in plot with 384 trees/ha (1.85 t/ha). Lowest leaf deposit was noticed in plot with 156 trees/ha (0.4 t/ha) (Table 2.5). The nutrients available for recycling in leaf deposits were maximum in high tree density plots (400 and 500 trees/ha) and lowest 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. Effect of tree density on leaf nutrient contents indicated no definite trend.

Among different tree density treatments, maximum yield of 970, 893 and 625 kg/ha was realized from plots with 384, 312 and 236 trees/ha respectively (Table 2.6). These plots had maximum sun exposed canopy areas. Minimum yield in high tree density plots with 400 and 500 trees/ha was observed (544 and 536 kg/ha respectively). The sun exposed canopy areas of trees in the above plots were also minimum. The reduction in yield in high tree density plots (400 and 500 trees/ha) may be due to shade induced branches producing weak panicles and later drying of branches due to depleted soil moisture at lower depths resulting in competition for moisture by the adjacent tree during peak summer season. Drying of lower shaded branches was due to moisture stress during peak summer season as it was noticed in March and not in December.

Table 2.5: Total leaf deposit collected and its nutrient content.

Spacing (m)	Density (Nos/ha)	Leaf deposit (t/ha)	N (kg/ha)	P (kg/ha)	K (kg/ha)
5 x 5	400	2.34	16.8	0.45	2.24
6.5 x 6.5	236	0.79	6.32	0.25	1.11
8 x 8	156	0.40	3.20	0.13	0.56
5 x 4	500	2.80	17.44	0.62	2.70
6.5 x 4	384	1.85	14.80	0.59	2.59
8 x 4	312	1.39	11.12	0.44	1.94

Pruning resulted in significantly higher yield compared to no pruning in all the treatments except lowest tree density plot (156 trees/ha) (Table 2.6). Highest cumulative yield under pruning conditions was realized from high tree density plots (3120 and 2699 kg/ha in 400 and 500 trees/ha respectively) and under no pruning, highest yield was recorded in plots with 500 and 384 trees/ha (3114 and 2673 kg/ha). Lowest cumulative yield was realized from plot with 156 trees/ha both under pruned and unpruned conditions (1077 and 1213 kg/ha).

2.2 Canopy management studies in cashew

Canopy management studies have been initiated during the year 1992-93 with an objective of studying the effect of pruning on canopy containment, flushing and flowering and yield of cashew. Four cashew varieties viz., VRI-1, Ullal-1, VTH 30/4 and NRCC

Sel-1 were used for these studies. Pruning treatments are yearly pruning (Leader shoot pruning + general pruning), alternate year pruning (leader shoot + general pruning) and shape pruning (general pruning). An unpruned control plot was also maintained for comparison. The pruning treatments were imposed since 1995 onwards and the 3rd cycle of pruning has been completed during the year 2000.

2.2.1 Effect on plant growth

Maximum canopy spread was observed in plants which were not given any pruning treatments and it was more in NRCC Sel-1 variety followed by Ullal-1 and VTH 30/4 (Table 2.7). Yearly pruned trees irrespective of variety had significantly lower canopy spread. Number of flowering laterals and non-flowering laterals remained unaffected due to leader shoot pruning. The length of lateral shoots, however, was reduced due to leader

Table 2.6: Effect of spacing and system of planting under pruned and unpruned conditions on yield ten years after planting.

Spacing (m)	Density (Nos/ha)	Yield/tree (kg)		
		Pruned	Unpruned	Mean
5 x 5	400	1.623	1.060	1.34
6.5 x 6.5	236	2.840	2.460	2.43
8 x 8	156	2.907	3.150	3.03
5 x 4	500	1.203	0.973	1.09
6.5 x 4	384	2.647	2.467	2.56
8 x 4	312	3.000	2.727	2.86
Mean		2.37	2.14	
CD for spacing yield/tree				1.12
CD for pruning yield/tree				0.57
Interaction				NS

Table 2.7: Effect of pruning on plant growth.

Treatment	Canopy spread (m ²)	Number of laterals / m ²		Length of laterals (cm)		Number of laterals/ leader shoot	
		Flowering	Non-flowering	Flowering	Non-flowering	Flowering	Non-flowering
A. Varieties							
VRI-1	5.76	20.08	5.92	29.71	11.36	2.15	2.09
Ullal-1	6.42	16.66	7.17	26.49	11.63	1.90	1.89
VTH 30/4	6.22	21.08	5.08	28.39	11.48	1.86	1.97
NRCC Sel-1	6.52	20.25	6.33	30.04	16.50	1.90	2.05
CD (0.05)	0.66	NS	1.36	0.84	0.63	0.16	0.15
B. Pruning							
No pruning	6.98	18.91	5.83	31.16	14.55	1.69	1.60
Yearly pruning	5.53	18.66	6.17	24.74	9.80	1.75	2.15
Alternate year pruning	6.12	19.23	6.50	27.80	12.04	2.20	1.87
Shape pruning	6.29	17.25	6.00	30.93	14.56	2.17	2.31
CD (0.05)	0.66	NS	NS	0.84	0.85	0.16	0.15
A x B CD (0.05)	0.99	NS	NS	1.70	1.27	0.32	0.31

Table 2.8: Effect of pruning on cashew yield.

Treatment	Cumulative yield of first five harvests	Yield during 1999-2000 (kg)	No. of nuts/panicle	Weight of nut (g)
A. Varieties				
VRI-1	13.52	3.82	5.00	6.16
Ullal-1	14.42	4.12	10.50	6.98
VTH 30/4	14.78	4.50	6.42	8.93
NRCC Sel-1	14.37	4.05	6.50	8.63
CD (0.05)	NS	0.36	3.11	
B. Pruning				
No pruning	14.60	4.34	7.75	7.68
Yearly pruning	13.68	4.03	4.58	7.56
Alternate year pruning	13.88	3.70	7.33	7.68
Shape pruning	14.91	4.37	8.75	7.77
CD (0.05)	NS	NS	1.45	0.10
A x B CD (0.05)	NS	NS	2.90	NS

Table 2.9: Soil and leaf nutrient contents.

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

shoot pruning. The number of laterals per leader shoot either flowering or non flowering though differed significantly the difference was negligible.

2.2.2 Effect on yield

The annual nut yield from pruned and unpruned trees and also the cumulative yield of first five harvests remained similar (Table 2.8). Number of nuts harvested per panicle in yearly pruned trees was significantly lower compared to control as well as other pruning treatments. Although weight of the nut varied significantly the difference was negligible.

2.2.3 Soil nutrient status

The soil nutrient status with respect to NPK content was similar in all the plots (Table 2.9). The soil organic content was slightly higher in plots with Ullal-1 and NRCC Sel-1 varieties where yearly shape pruning was done. The leaf nutrient with respect to NPK content remained unaffected due to various pruning treatments.

2.3 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 for increasing the cashew yield are being evaluated under this programme.

Main plot treatments (4)

1. Individual tree terracing with catch pit.
2. Individual tree terracing with crescent bunding.

3. Staggered trenches between two rows of cashew.
4. Control plot without any soil conservation technique.

Sub plot treatments

1. Application of recommended doses of fertilizers only (750 g N : 150 g each of P_2O_5 and K_2O /tree/year).
2. Application of recommended doses of fertilisers + organic manure (10 kg poultry manure).
3. 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 (227% of control -without any soil conservation). The treatments like individual terracing and catch pit and staggered trenches did not influence yield significantly. Application of recommended doses of fertilizers with poultry manure (10 kg) and poultry manure alone (20 kg) resulted in significantly higher yield than recommended doses of fertilizer application alone. Interaction effects of both soil conservation measures and manures were not observed (Table 2.10).

In an observational trial on soil conservation and irrigation, coconut husk

Table 2.10: Effect of soil and water conservation coupled with organic and inorganic manure on the yield of cashew (kg/tree).

Treatment	Sub plots			Mean
	1	2	3	
Individual tree base terracing with catch pit	0.96	1.37	1.33	1.22
Individual tree base terracing with crescent bunding	1.24	2.04	1.64	1.64
Staggered trenches between two rows of cashew	0.95	1.45	1.47	1.29
Control plot without any soil conservation technique	0.64	0.71	0.82	0.72
Mean	0.95	1.39	1.32	
CD for Main Plot (0.05)				0.526
CD for Sub Plot (0.05)				0.224
Sub Plot 1	Application of recommended doses of fertilizers only.			
Sub Plot 2	Application of recommended doses of fertilizers and organic manure.			
Sub Plot 3	Application of organic manure only (20 kg)			

burial between two rows of cashew resulted in 300% of higher yield compared to control plot receiving neither irrigation nor soil conservation. Similarly with irrigation and soil conservation, the yield was 400% of control plot (no irrigation and soil conservation).

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

The programme aims at increasing the productivity of cashew by adopting an integrated approach of nutrient management. The following are the main objectives of the programme.

- 1) Nutrient budgeting and balance studies through system approach in high density cashew system.

- a) To study and quantify the various processes involved in nutrient enrichment and nutrient depletion.
- b) To develop a system model for nutrient enrichment and depletion processes.
- c) To work out economics of the system with special reference to cost benefit ratio.

- 2) Organic farming technology for utilization of farm waste for integrated nutrient management.

- a) To develop suitable technique for generating green biomass.
- b) To develop a suitable and viable method of composting wastes available in cashew garden.

- c) To study the nutrient release pattern of the composts and its quality evaluation.
- d) To study the impact of applied organic manures on the response of cashew.
- e) To work out economics of organic farming system and integrated approach of both organic and inorganic farming system.

2.4.1: Nutrient requirement studies in high density planting.

The experiment was laid out during the year. Treatments were imposed on three year old cashew grafts of Goa 11/6 variety planted at 4m x 4m spacing. The details of the treatments are as follows. Treatments were imposed in five replicated plots in Randomized Block Design.

Treatments:

- 1) No fertilizer application
- 2) Application of fertilizers at $\frac{1}{3}$ rd of the recommended dose (250 g N, 50 g P₂O₅ and 50 g K₂O)
- 3) Application of fertilizers at $\frac{1}{2}$ of the recommended dose (375 g N, 75 g P₂O₅ and 75 g K₂O)
- 4) Application of fertilizers at full dose (750 g N, 150 g P₂O₅ and 150 g K₂O)

Collection of leaf biomass along with cashew farm waste was done treatment wise at quarterly time intervals. Total cashew farm waste collected so far indicated no significant

difference among the treatments. Mechanical and chemical analysis of soil before imposing treatments were taken up. The soil is categorised as gravelly sandy clay loam. N (< 280 kg/ha) and K (< 180 kg/ha) contents in soil are low and P content are from medium to high level (12.76 - 31.71 kg/ha).

2.4.2 Cashew based cropping system

(i) Cashew with green manuring crops

Design : RBD
Treatments : 5
Variety : Goa 11/6
Replications : 5

- 1) Cashew with sunhemp
- 2) Cashew with sesbania
- 3) Cashew with glyricidia
- 4) Cashew with cover crop
- 5) Cashew alone

(ii) Cashew with other crops

Design : RBD
Treatments : 5
Variety : NRCC Selection-2
Replications : 5

- 1) Cashew with groundnut
- 2) Cashew with turmeric
- 3) Cashew with cowpea
- 4) Cashew with pineapple
- 5) Cashew alone

The planting of main crop (cashew) was done after clear felling of existing old cashew garden. The plots for taking up planting of green manuring crops and inter crops have been prepared. Soil samples have been collected for determination of N, P and K contents.

2.4.3 Integrated nutrient management for sustainable production of cashew

In order to develop suitable combinations of organic and inorganic manures for increasing yield, an experiment was laid out in 1999 with revised treatments.

- i) No fertilizer application.
- ii) 100% N of recommended fertilizer dose.
- iii) Bio-fertiliser - Azospirillum with cashew farm waste compost.
- iv) Bio-fertiliser - Azatobacter with cashew farm waste compost.
- v) 25% N of recommended fertilizer dose and remaining through cashew farm waste compost.
- vi) 50% N of recommended fertilizer dose and remaining through cashew farm waste compost.
- vii) 75% N of recommended fertilizer dose and remaining through cashew farm waste compost.
- viii) 25% N of recommended fertilizer dose and remaining through application of poultry manure.
- ix) 50% N of recommended fertilizer dose and remaining through application of poultry manure.
- x) 75% N of recommended fertilizer dose and remaining through application of poultry manure.

Organic matter and available N contents were significantly more in plots

receiving 75 to 100% N in the form of cashew waste compost and poultry manures compared to 50, 25 and 0 N in the form of organic manure and remaining in the form of inorganic manures. Available N was low in all the other treatments. Available P_2O_5 contents in the soil did not vary significantly due to different manurial treatments. Levels of K were medium in treatments receiving 100% N in the form of inorganic manure, and 25% in the form of composted cashew farm waste and remaining in the form of inorganic manures.

In a trial conducted on organic and inorganic manures, application of recommended dose of NPK @500:125:125 g/tree and 10 kg poultry manure resulted in higher yield corresponding to 235% of control plot receiving no fertilizers and poultry manures. The yield from the plot receiving fertilizers alone was 153% of control plot. Similarly, the yield realised from the plot receiving poultry manure also was 114% of control plot (Table 2.11). The application of recommended doses of fertilizers and 10 kg of poultry manure is beneficial in realising higher yield.

2.4.4 Composting of cashew waste

Design	:	RBD
Treatments	:	8
Replications	:	3

- 1) Only cashew waste composting
- 2) Cashew waste + application of cowdung slurry at 10% of total weight of cashew waste

Table 2.11: Effect of manures on the yield of cashew (kg/tree)

Treatment	VRI-1	VRI-2	Mean	% of control
Full dose of NPK @ 500:125:125 g/tree	1.32	2.76	2.040	153
Poultry manure @ 20 kg/tree (Full dose)	1.36	1.676	1.518	114
Full dose of NPK @ 500:125:125 g/tree plus half dose of poultry manure @ 10 kg/tree	1.110	5.14	3.125	235
Half dose of NPK @ 250:62.5:62.5 g/tree plus half dose of poultry manure @ 10 kg/tree	2.57	3.23	2.900	218
No NPK and no poultry manure (Control)	1.130	1.530	1.33	100
Mean	1.498	2.867		
CD for Main plot			1.26	
CD for Sub plot			1.07	
CD for Interaction			NS	

- 3) Cashew waste + application of cowdung slurry at 20% of total weight of cashew waste
- 4) Cashew waste + application of urea solution (0.5%)
- 5) Cashew waste + 1.25 kg Rock phosphate/100 kg of cashew waste
- 6) Cashew waste + Urea 0.5% + 1.25 kg Rock phosphate/100 kg of cashew waste
- 7) Cashew waste + cowdung slurry (10%) + 1.25 kg Rock phosphate/100 kg of cashew waste)
- 8) Cashew waste + P solubilizing organism + application of cowdung slurry at 10% of total weight of cashew waste

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

Chemical analysis indicated that cashew waste composted after the application of 20% of total weight of cashew waste with cowdung slurry had maximum contents of N, P and K compared to all other treatments. Minimum nutrient contents were found in cashew waste without adding any activator (Table 2.12). Microbial load in the cashew waste compost was analysed in the samples collected from four locations from Japanese compost chamber (Table 2.13).

2.4.5 Preparation of vermicompost from cashew waste material

Cashew waste after treating with 15% cowdung slurry was decomposed for 20 days and earthworms were allowed to feed on this. Vermicompost formed was rich in N, P, K, Ca and Fe (Table 2.14). In one ton of partially decomposed cashew waste, 0.35 t of vermicompost was produced from cashew waste within five months of introduction of earthworms (*Eudrilus* sp.).

Table 2.12: Nutrient content of cashew waste compost.

Nutrients	Cashew waste added with cowdung slurry (20% of total weight)	Cashew waste material without adding any activator
N (%)	1.59	0.81
P (%)	0.53	0.08
K (%)	0.33	0.14
Ca (%)	0.94	0.22
Mg (%)	0.56	0.19
Zn (ppm)	0.60	1.00
Mn (ppm)	74.5	31.4
Cu (ppm)	4.02	0.60
Fe (ppm)	86.00	49.85

Table 2.13: Microbial population in compost sample.

Microorganism	No./g
Bacteria	24×10^6
Fungi	14×10^4
Actinomycetes	13×10^6
Phosphate solubilizer	Nil
Azospirillum	1.1×10^4

Table 2.14: Nutrient content of vermicompost.

Nutrients	Value
N (%)	1.2
P (%)	0.9
K (%)	0.60
Ca (%)	2.76
Mg (%)	0.83
Zn (ppm)	29.7
Mn (ppm)	24.5
Cu (ppm)	12.4
Fe (ppm)	162

2.5 Root stock studies

Root stock studies are being conducted to understand the role of root stocks on canopy growth of scion variety and to induce

dwarfing in cashew through chemical intervention.

2.5.1 Trial on root stocks

An experiment was started during 1996 with air layers of five root stocks - one tall type (Selection-1) and four semi-tall types (VTH 762/2, VTH 762/4, S 11/1 and S 11/2). Some of these air layers were also *in situ* grafted with the scions of a tall and vigorous growing type (Selection-1) during July 1997, in order to study the influence of root stocks on the growth of scion variety (Selection-1).

The mean plant height of Selection-1 root stock (four years and three months after planting) was the highest (4.11 m) as compared to that of semi-tall root stocks (mean plant height ranged from 1.88 - 3.10 m) (Fig.2.1). The canopy spread and trunk girth were also more in Selection-1 as compared to that in semi-tall root stocks (Fig.2.2 & 2.3).

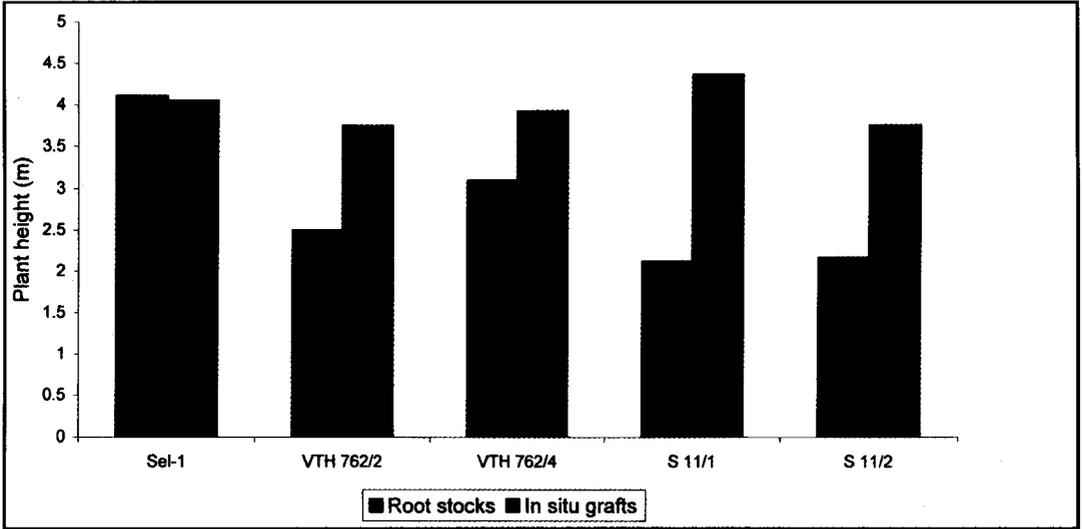


Fig. 2.1: Plant height of root stocks and their *in situ* grafts with Selection-1

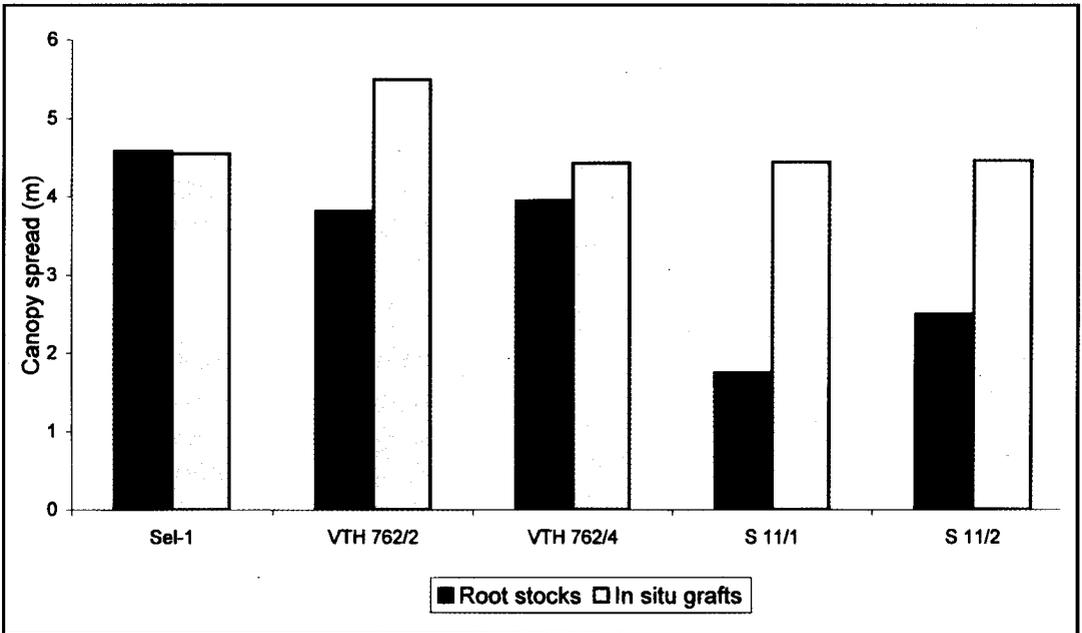


Fig. 2.2: Canopy spread of root stocks and their *in situ* grafts with Selection-1

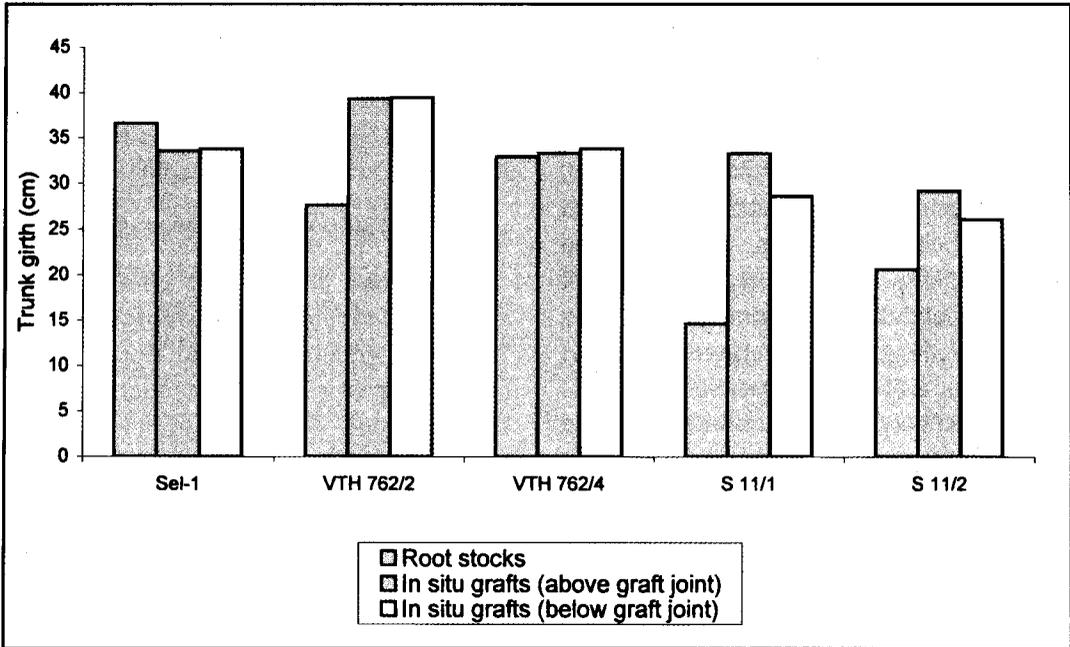


Fig. 2.3: Trunk girth of root stocks and their *in situ* grafts with Selection-1

The growth parameters recorded on *in situ* grafts of these root stocks with scions of Selection-1 (three and half years after grafting) has shown that irrespective of the root stocks used, the growth of scion variety (Selection-1) was found to be taller and vigorous. The mean plant height, canopy spread and trunk girth - above graft joint and below graft joint, of all the *in situ* grafts involving different root stocks have shown that the scion variety (Selection-1) is taller and vigorous (Fig.2.1, 2.2 and 2.3). The mean plant height ranged from 3.75 - 4.37 m, the canopy spread from 4.43 - 5.50 m and the trunk girth - above graft joint from 29.3 - 39.4 cm; trunk girth - below graft joint from 26.2 - 39.5 cm. However, the plant height, canopy spread and trunk girth of *in situ* grafts are comparable with that of Selection-1 root stock. Results presented have indicated that the root

stocks tested did not influence the growth of scion variety.

2.5.2 Induction of dwarfing through chemical intervention

1) Trial on paclobutrazol:

In order to study the effect of soil application of paclobutrazol (Cultar 25% FC), an antigibberellin biosynthate, on growth of cashew, a field trial was conducted for three years (from 1998-99 to 2000-2001) on ten year old plants of Vengurla-3 in the scion bank. The experiment was laid out in Randomised Block Design with split plots and replicated four times. Paclobutrazol @2g, 4g, 6g and 8g ai/plant (M_2 , M_3 , M_4 and M_5) was applied through collar drenching (S_1) and in circular ring mid way between trunk and drip line at 15 cm depth (S_2) in the month of September



(pre-flushing). Paclobutrazol at different concentrations was dissolved in 5 litres of water and applied. Treatment without the application of paclobutrazol (M_1) served as control. Significant differences among different doses of paclobutrazol were observed for plant height increment, canopy spread increment, number of flushes/ m^2 , number of flowering laterals/ m^2 , percentage flowering laterals/ m^2 , length of flowering laterals and length of non-flowering laterals. Significant differences between collar drenching and circular ring method of applications were not observed. Increased dosage of paclobutrazol reduced the plant height increment, canopy spread increment, length of flowering and non-flowering laterals and increased the number of flushes/ m^2 , number of flowering laterals/ m^2 , percentage flowering laterals/ m^2 as compared to control. Soil application of 6-8 g a.i. paclobutrazol/plant was found to be effective in reducing the plant height increment (50.0 and 51.7%), canopy spread increment (58.9 and 57.5%), length of flowering laterals (38.9% and 55.3%), length of non-flowering laterals (69.0 and 74.4%) as compared to control. This has also increased the number of flushes/ m^2 (38.6 and 64.2%),

number of flowering laterals/ m^2 (70.9 and 127.4%) and percentage of flowering laterals/ m^2 (13.7 and 22.8%). Soil application of 6-8 g a.i. of paclobutrazol/plant was found to be effective in containing the canopy.

2) Trial on chlormequat chloride:

In order to study the effect of foliar application of chlormequat chloride (Lihocin 50 AS) on growth and yield of cashew, an observational trial was conducted during 1999-2000 and 2000-2001, on three year old plants of "Kanaka" variety in the scion bank. Chlormequat chloride @500, 1000, 1500, 2000 and 2500 ppm was applied through foliar application during preflushing (September) and post flushing (November) period. Each dosage of chlormequat chloride was sprayed on each plant to run off (500 ml solution/plant). Microwet (surfactant) @ 1ml/litre of spray solution was also added. Treatment without application of chlormequat chloride as control was also included for comparison. Compared to control, application of chlormequat chloride @2500 ppm has reduced the plant height, canopy spread, length of flowering laterals and length of non flowering laterals.

3. CROP PROTECTION

In order to develop management strategy against cashew stem and root borers, studies were undertaken on identification of kairomones from cashew plant parts, phytosanitation, and physical parameters influencing recovery of infested trees. For the management of tea mosquito bug, newer and safer insecticides were evaluated. Performance of Goa 11/6 an accession which escapes TMB infestation was also studied. Studies were also undertaken for determination of levels of residues of different insecticides in cashew kernels.

3.1 Cashew Stem and Root Borer (CSRB)

3.1.1 Studies on kairomones from cashew plant parts

Extracts and volatiles collected in n-hexane from both healthy and infested frass

were analysed by GCMS. Compounds identified in both extracts and volatiles of healthy bark and frass were; dichlorobenzene, dodecane, tri-decane, tetradecane, pentadecane, hexadecane and heptadecane. Extract from frass specifically contained ericosane, cyclohexanol, dimethyl ethylphenol and octonoic acid. Frass volatiles had dimethyl ethyl phenol and naphthalene which were absent in other extracts and volatile concentrates (Table 3.1).

Among the compounds tested for EAG response, methyl myristate (140.2%), cyclohexanol (135.1%), phthalic acid (108.1%) and methyl cyclopentane (107.9%) had higher response compared to geraniol (100%). Similarly naphthalene (99.6%), cyclohexane (83%), methyl ester of decanoic

Table 3.1: Compounds identified by GCMS as per Rembold's method.

Sample	Compounds identified (> 80% matching)
Hexane extract of healthy bark	Pyridine, 1,2-benzene dicarboxylic acid, dodecane, hexadecane, tridecane, tetradecane, pentadecane, phenol, heptadecane and hexatriacontane.
Hexane extract of frass	Cyclohexanol, dichlorobenzene, octanoic acid, dodecane, hexadecane, tridecane, decanoic acid, tetradecane, pentadecane, dimetyl ethyl phenol, dodecanoic acid, eicosane and heptadecane.
Volatiles of healthy bark in hexane	Dichlorobenzene, naphthalene, dodecane, tetradecane, cyclohexadione, tetradecane, pentadecane and hexadecane.
Volatiles of frass in hexane	Dichlorobenzene, naphthalene, dodecane, tetradecane, tridecane, pentadecane, dimetyl ethyl phenol and hexadecane.
Hexane extract of cashew apple aroma distillate	Cyclohexanol, dichlorobenzene, limonene, undecane, naphthalene, dodecane, benzotriazone, decanoic acid, hexadecane, tetradecane, heptacosane, heptadecane.



acid (81.2%), 1,2-dichloro benzene (80.9%) and phthalic acid (79.9%) had lower response compared to geraniol (100%). Response of methyl arachidate (49.6%), cyclopentane (45.8%), and all the hydrocarbons tested had response less than 50% compared to geraniol. Least response was noticed in n. hexadecane (16.4%) compared to geraniol. Thus methyl myristate and cyclohexanol appear to be promising.

In order to see whether combination of two compounds elicit higher response, mixture of different compounds were prepared and tested for inducing response from mated adult females of CSRB. The mixtures namely methyl cyclopentane and naphthalene (1:1 v/v), cyclohexane and 1,2-dichlorobenzene (1:1 v/v), cyclohexanol and phthalic acid (1:1 v/v) and methyl myristate and phthalic acid (1:1 v/v) were evaluated for their ability to induce response from mated adult females of CSRB. Among the four mixtures evaluated, mixture of cyclohexanol and phthalic acid had higher response (133.7%) compared to phthalic acid (72.1%) and geraniol (100%). In all the other combinations additive effect was not observed. Thus mixture of cyclohexanol and phthalic acid (1:1 v/v) appears to be better.

3.1.2 Trials on phytosanitation

Phytosanitation was adopted during 1998-99 by uprooting trees beyond recovery (> 50% bark circumference damaged and / or yellowing of canopy), and later removing CSRB grubs occurring in root zone and in inaccessible portions such as fork of roots. The number of trees showing fresh attack during each year was recorded for each experimental plot separately. During 1999-2000, fresh pest incidence was reduced

in five plots out of ten plots observed. During 2000-2001, five plots out of 12 plots observed had reduced fresh incidence of the CSRB. Further the observations on number of grubs collected in different experimental plots showed reduction in eight out of 12 plots observed, which indicated reduced pest infestation due to phytosanitation (Table 3.2).

3.1.3 Physical characters of infested trees

Physical characters such as stem girth, age of trees, zone of attack, percentage of bark circumference damaged and stage of infestation were recorded for all the CSRB infested trees. Of the individual parameters, stage of infestation and percentage of bark circumference damaged strongly influenced the recovery of the infested trees. The zone of attack also had moderate influence on recovery.

It was observed that 100% of trees in initial stages of infestation, 96% of trees having less than 25% bark circumference damaged and 65% of trees having collar and stem infestation could recover. The effect of various combinations of parameters on recovery is being compiled for the data of previous years.

3.1.4 Population dynamics of CSRB

Based on the technique developed for age-estimation of field collected CSRB grubs by measuring the pro-thoracic shield (PTS) width, the probable egg laying period was estimated. Egg deposition was noticed to have occurred in all months, while peak egg laying occurred during December - April. As this period coincides with the nut collection period, it is possible to trace the initial infestation symptoms effectively and timely curative measures can be adopted (Fig.3.1).

Table 3.2: Effect of phytosanitation on fresh infestation by CSRB.

Plots	Percentage of trees having fresh CSRB attack			No. of CSRB grubs collected	
	Upto Feb 1999	Upto Feb 2000	Upto Feb 2001	Upto Feb 2000	Upto Feb 2001
Kemminje					
NCCB	3.91	3.35	2.65	436	126
Expt. V	1.97	4.69	3.44	118	18
Expt. VI	12.0	6.7	7.79	574	19
Expt. VIII, IX, X	-	4.4	3.3	195	88
Expt. XI, XIIB	0.87	1.58	3.89	45	97
Expt. XIIA	5.66	7.35	8.72	258	49
Expt. XIIC, XIII	-	2.0	1.6	13	24
Expt. XIVA	4.67	4.2	5.7	81	57
Shanthigodu					
Drip irrigation	1.4	0.8	1.43	37	66
Canopy Management Studies	1.94	2.78	2.80	27	66
Elite germplasm evaluation	13.4	6.25	6.76	288	45
Intercropping trials	0.79	1.75	0.16	33	31

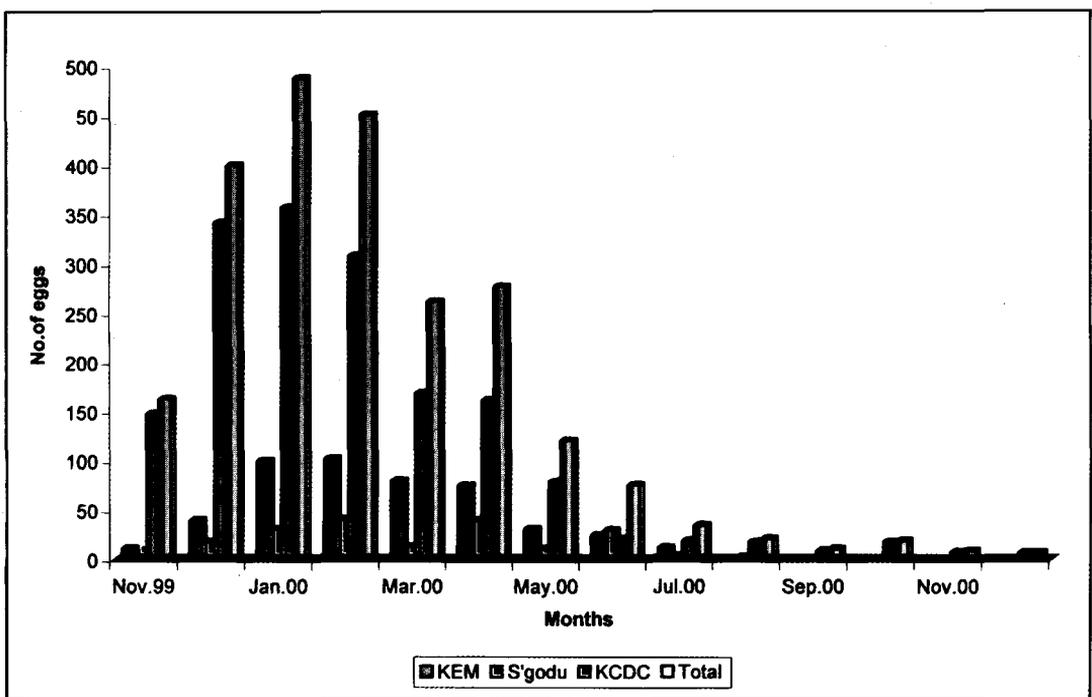
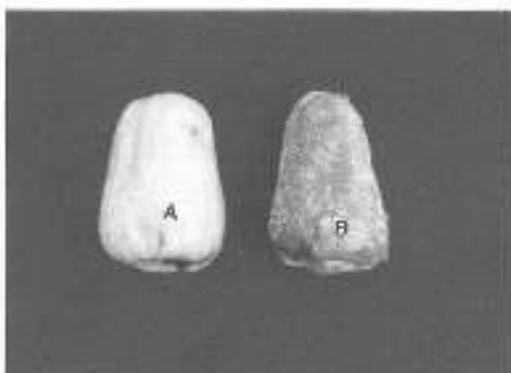


Fig. 3.1: Estimated egg laying by CSRB during different months.

Studies on estimation of age by measuring head capsule width has been initiated for comparison.

3.1.5 Multiplication of *Metarhizium anisopliae* on cashew apple

Ripe cashew apples were found to be suitable for multiplication of *M. anisopliae*. The spore production when multiplied on cashew apple was 38.69 - 56.55% compared to jowar grains 75 days after application (Table 3.3). Suitability of cashew apple for multiplication of *M. anisopliae* was studied under field conditions also. The cashew apples were mixed with *M. anisopliae* and applied to the base of tree trunk. At monthly intervals the grubs were released at the site of application and allowed to feed for 24h. Later, these grubs were removed and observed for disease development under laboratory condition. All the grubs observed died due to mycosis in the releases made upto three months of fungal application at the tree base. The study indicated that the spores are viable for a minimum period of three months under the field condition.



Multiplication of *Metarhizium anisopliae* on cashew apple

3.1.6 Semi-synthetic diet (SSD) for rearing CSRБ grubs.

Grubs of CSRБ were reared on semi-synthetic diet right from nascent stage. The composition of diet is given in Table 3.4. The SSD was found to be suitable for the development of CSRБ grubs. After 120 days of hatching, higher percentage of survival (76%) on SSD was observed compared to grubs grown on host bark (64%) (Table 3.5).

Table 3.3: Spore production of *Metarhizium anisopliae* on cashew apple (No./g).

Treatment	Days after inoculation	
	45	75
Cashew apple pre-washed with distilled water	0.46 x 10 ⁶	0.65 x 10 ⁶
Cashew apple surface sterilized with 10% alcohol	0.80 x 10 ⁶	0.95 x 10 ⁶
Jowar grains	0.92 x 10 ⁶	1.68 x 10 ⁶

Table 3.4: Composition of semi-synthetic diet (SSD).

Ingredient	Quantity (g)
Host bark	100
Bengal gram powder	105
Sucrose	75
Agar-agar	22
Yeast	15
Ascorbic acid	6
Methyl para benzoate	3
Sorbic acid	1.5
Griseofulvin	1.5
Multivitamin drops	6 ml
Formalin	Few drops
Distilled water	665 ml

Table 3.5: Development of grubs of *P. ferrugineus* on semi-synthetic diet (SSD) and host bark.

Age of grubs (days)	Weight gain (g)		% increase over host bark	% survival	
	Host bark	SSD		Host bark	SSD
30	0.240	0.320	33.33	92.00	92.00
60	0.631	0.840	33.12	80.00	88.00
90	1.178	1.510	28.18	76.00	80.00
120	2.012	2.456	22.07	64.00	76.00

3.2 Tea Mosquito Bug (TMB)

3.2.1 Host plants

During August-September, a confirmative study was undertaken to find out whether Singapore cherry tree serves as breeding host or feeding host for TMB. It was found that in addition to *Helopeltis antonii*, *H. bradyi* also infests this tree. Hence Singapore cherry could act as a breeding host (refugee host) for both the species of TMB. However, their population as well as damage declined from November onwards.

3.2.2 Chemical control

One new insecticide (Imidachloprid) was sprayed individually on young trees at

two concentrations (0.01 and 0.02%). TMB nymphs and adults were caged on the same day, 3rd day and 7th day after spraying. Survival of the population and damage score (0-4 scale) were recorded 24 and 48 h after caging respectively. Similarly, to find out the ovicidal and residual action against 1st instar nymphs, the above insecticides were sprayed on a set of damaged seedlings having TMB eggs along with healthy seedlings with tender flushes. Both damaged TMB egg laden and healthy treated seedlings were tied together in such a way that the newly hatched nymphs can migrate and feed on the tender flushes of healthy treated seedlings. The damage was scored on 3rd day after hatching of nymphs (Table 3.6 and 3.7). Results indicated

Table 3.6: Residual effect of imidachloprid on survival of nymphs / adults and damage of TMB.

Concentration (%)	No. surviving after 24 h				Damage grade (0-4 scale) 48 h after caging			
	Same day	3rd day	7th day after spraying	Mean	Same day	3rd day	7th day after spraying	Mean
0.01	0.0aA	0.0aA	0.6aB	0.3a	0.6aA	0.4aA	1.6aB	1.5a
0.02	0.0aA	0.0aA	1.0aB	0.6a	0.2aA	0.4aA	2.2aB	0.9a
Control	6.0bA	6.0bA	6.0bA	6.0b	3.0bA	3.0bA	3.4bA	3.1b
Mean	2.0A	2.0A	2.5B		1.3A	1.3A	2.4B	

Mean followed by common small letter in each column or common big letter in each row is not significantly different at 5% L.S.D.

Table 3.7: Residual effect of imidachloprid on oviposition of eggs and damage of 1st instar nymph of TMB.

Concentration (%)	No. of eggs/female laid during 48 h				Hatching of eggs (%)	Damage grade by 1st instar nymphs
	Same day	3rd day	7th day after spraying	Mean		
0.01	0.0	0.6	0.2	0.3a	94.6	0.0a
0.02	0.0	0.0	0.8	0.3a	100.0	0.0a
Control	23.0	24.6	25.4	24.3b	100.0	4.0b
Mean	7.7	8.4	8.8		NS	

Mean followed by common small letter in each column or common big letter in each row is not significantly different at 5% L.S.D.

NS Non significant

that efficacy against TMB at both concentrations are on par with each other. It had shown significant residual action against TMB nymphs/adults along with highest oviposition deterency and residual action against 1st instar nymphs of TMB for seven days.

3.2.3 Biological control

Nymphal and adult population (NAP) of TMB were periodically sampled for the presence of nymphal adult parasitoid (NAP). Out of 912 nymphs and adults of TMB examined from January to December 2000, occurrence of NAP was very low (0.7%).

The egg endoparasitoids *Telenomus sp.* and *Chaetostricha sp.* of TMB were encountered in TMB eggs collected from sprayed (monocrotophos / carbaryl) plots with highest parasitism of 51.4% (Fig.3.2). But their relative emergence during severe infestation period of TMB (January-March) was on lower side and therefore, the insecticidal application can be practised with

least adverse effect on egg parasitism on TMB.

A survey was undertaken to find out the extent and species composition of egg parasitoid under both west and east coast condition. It was found that under west coast conditions (coastal Maharashtra, Karnataka and Kerala) *Telenomus sp.* was dominant whereas, it was not observed under the east coast condition (Orissa, Andhra Pradesh and Tamil Nadu). Further the extent of egg parasitism in west coast was quite prominent (35.6 to 62.5%) and it was least (Nil to 21.6%) under east coast condition (Table 3.8).

3.2.4 Varietal resistance

The yield performance of the TMB escape accession (Goa 11/6) planted at closer spacing of 6m x 6m and maintained under unsprayed condition over a period of 11 years is being assessed. During the current year an yield of 2.62 t/ha (mean yield/tree : 9.44 kg; (SD ± 2.89 kg; relative variation : 10.8%) was obtained in eight harvests. The yield was in

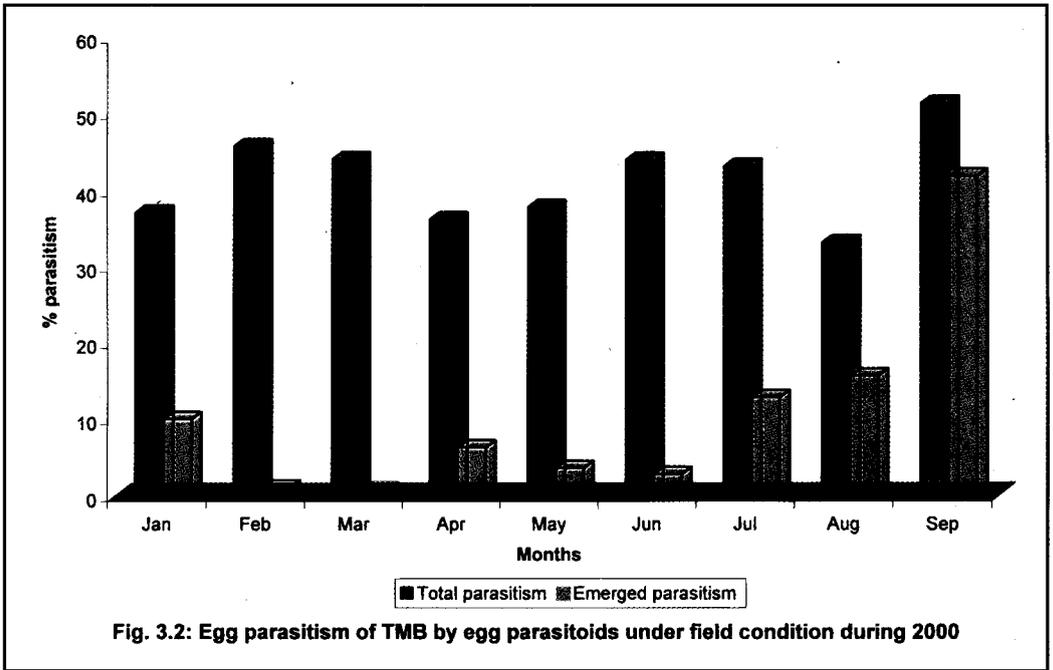


Fig. 3.2: Egg parasitism of TMB by egg parasitoids under field condition during 2000.

Table 3.8: Egg parasitism in the sprayed plots in west coast and east coast of India during March and May 2000.

Location	% egg parasitism		
	Total	Species composition	
		NTG	TG
West Coast			
Vengurla	43.9	13.3	30.6
Bramhavar	35.6	0.0	35.6
Karkala	46.7	8.3	38.4
Ullal	62.5	8.3	54.2
Madakkathara	45.9	0.0	45.9
East Coast			
Vridhachalam	10.3	10.3	0.0
Palasa	21.6	21.6	0.0
Puri	0.0	0.0	0.0

NTG - Non *Telenomus* group

TG - *Telenomus* group

the range 5.3 to 17.1 kg/tree and the TMB infestation was very low to moderate. In this plot besides regular inorganic fertilizer application, the crop residue (leaf litter), annual weeds and legumes (*Crotalaria laevigata* and *Atylosia lineata*) were incorporated into the soil. The legume litter eating caterpillars also hastened decomposition of legume litters from *Mimosa* and *Crotalaria* spp.

3.3 Standardisation of protocol for determination of residues of lindane and endosulfan

1) Lindane

Two methods were standardized for detection of residues of lindane in cashew kernels. In the 1st method, powdered kernel sample was homogenized with 35% water in acetonitrile. Residue was transferred to petroleum ether and digested with sulphuric acid. Concentrated samples were injected into Gas chromatograph fitted with ECD and fused silica capillary pesticide analysis column. The required detector, injector and column temperatures are 240°C, 230°C and 210°C respectively. Recovery of residues is upto 87.5% in this method.

In the 2nd method, cashew kernel was homogenized in acetone, followed by extraction with n-hexane and digestion with sulphuric acid. The GC conditions are similar to the 1st method. Recovery of residues is upto 89.8% in this method.

2) Endosulfan

The kernel sample (50 g) was homogenised in 100 ml of acetone-hexane mixture (1:1, v/v). Reextraction was done twice with n-hexane (100 ml). Pooled organic phase was evaporated till almost free of the solvent and the residue was dissolved in 100 ml of petroleum ether. This fraction was washed with water, passed through anhydrous sodium sulphate and concentrated before injecting into GC. Recovery of residue is upto 86.5% in this method.

In the 2nd method, 50 g sample was homogenized with 125 ml of acetonitrile and water mixture (4:1) and the residue was taken in n-hexane (150 ml) and concentrated to about 20 ml. After washing with distilled water, organic phase was concentrated to 5 ml before injection into GC. Recovery of the residues is upto 88.6% in this method.

3.3.1 Determination of levels of different insecticides used in the management of cashew pests

1) Lindane

Lindane treatment was done to the base of the tree against cashew stem and root borers at recommended concentration (0.2%) and double the recommended concentration (0.4%). The nut samples were collected after 3, 7 and 14 days of treatment. Residue of lindane was not traced in any of the samples collected.



2) Endosulfan

Endosulfan spraying was done at recommended concentration (0.05%) and double the recommended concentration (0.1%) and the nut samples were collected after 3, 7 and 14 days of treatment. Residues were not detected in any of the samples analysed.

3) Residues in samples from farmers' fields

Rawnuts were also collected from farmers' fields and analysis was done to detect residues of lindane and endosulfan. Residues were not traced in the kernels in all the samples analysed.

4. POST HARVEST TECHNOLOGY

4.1 Value addition in cashew

4.1.1 Cashew spread

Sweetened spread prepared from cashew kernel bits was stored at low temperatures ($< 0^{\circ}\text{C}$ and $6-10^{\circ}\text{C}$) for a period of six months and the quality in terms of iodine value, peroxide value and acid value was assessed (Table 4.1). Both iodine value

and acid value increased during storage. Peroxides were not detected. The fact that the peroxides are not detected indicated that cashew spread has not undergone any quality deterioration. Cashew spread could be stored at $< 0^{\circ}\text{C}$ and $6-10^{\circ}\text{C}$ for a period of six months without organoleptic quality deterioration (Table 4.2).

Table 4.1: Keeping quality of cashew spread at low temperatures.

Storage temperature ($^{\circ}\text{C}$)	Storage period (months)	Iodine value	Acid value
< 0	0	18.4	12.8
	2	29.4	10.8
	4	26.7	13.3
	6	28.9	14.6
6-10	0	18.4	12.8
	2	27.9	7.8
	4	38.6	15.2
	6	38.7	13.5

Values are mean of two individual estimations

Table 4.2: Organoleptic analysis of sweetened and vanillin flavoured cashew spread during storage at low temperatures.

Storage temperature ($^{\circ}\text{C}$)	Storage period (months)	Mean cumulative hedonic score	
		Stored	Freshly prepared
< 0	0	-	16.3
	2	17.1	15.6
	4	18.1	17.1
	6	17.2	16.9
6-10	0	-	16.3
	2	17.0	15.6
	4	16.3	17.1
	6	16.5	16.9

Mean cumulative hedonic score represents the cumulative hedonic score for colour, flavour, consistency, spreadability and taste of sweetened and vanillin flavoured spread of 16 judges.

Studies on the comparison of refined oils extracted from cashew kernel baby bits, commercial sample of almond, ground nut and sunflower seeds have indicated that iodine value did not change during storage upto six months at 27-30°C. However, acid

value increased during storage. The increase in acid value was higher in almond, ground nut and sunflower oil as compared to oil from cashew kernel baby bits. These results have indicated that oil from cashew kernel baby bits has better shelf life (Table 4.3).

Table 4.3: Keeping quality of refined oils at ambient temperature (27-30°C)

Storage period (months)	Oils	Iodine value	Acid value
0	Cashew	84.3	0
	Almond	88.0	0
	Groundnut	84.2	0
	Sunflower	103.9	0.25
2	Cashew	87.2	0.435
	Almond	82.8	-
	Groundnut	94.2	1.43
	Sunflower	101.4	2.12
4	Cashew	85.3	0.581
	Almond	86.5	2.99
	Groundnut	88.3	2.40
	Sunflower	91.7	8.60
6	Cashew	88.9	0.96
	Almond	91.6	2.78
	Groundnut	90.3	4.18
	Sunflower	51.6	38.24

Values are mean of two individual estimations

4.1.2 Coating of cashew kernel baby bits

Studies on coating of baby bits were continued. Optimum coating of baby bits with honey and salt occurs at 70% and 5% respectively at 100°C. Cashew kernel baby bits after coating with cane sugar, honey and salt at different concentration were evaluated for colour, flavour, texture and taste. Cashew kernel baby bits coated with 50% cane sugar,

30% honey and 0.5% salt were the most preferred with mean cumulative hedonic score of 12.12, 12.82 and 14.26 respectively (Table 4.4 and 4.5). Studies on coating of cashew kernels of different grades with cane sugar have revealed that the per cent coating is directly proportional to the surface area of the kernel and inversely proportional to the size of the kernel (Table 4.6).

Table 4.4: Sensory evaluation of cashew kernel baby bits coated with cane sugar and honey at different concentrations.

Conc. (%)	Cane sugar		Honey	
	% coating	Mean cum. Hedonic score	% coating	Mean cum. Hedonic score
30	2.67	13.12	3.56	12.82
40	5.26	12.93	5.29	13.41
50	9.33	12.12	8.39	14.29
60	10.81	12.19	8.22	13.12
70	13.03	13.24	13.80	16.12
CD (0.01)		1.68	2.83	2.03

Per cent coating is the mean of three individual estimations. Mean cumulative hedonic score represents the cumulative hedonic score for colour, flavour, texture and taste of the coated cashew kernel bits of 20 judges.

Table 4.5: Sensory evaluation of cashew kernel baby bits coated with salt at different concentration.

Concentration (%)	% Coating	Mean cum. Hedonic score
0.5	0.153	14.26
1.0	0.884	14.63
2.0	1.88	14.68
3.0	3.14	15.53
4.0	3.56	15.63
5.0	4.73	16.63
CD (0.01)	0.203	2.06

Per cent coating is the mean of three individual estimations. Mean cumulative hedonic score represents the cumulative hedonic score for colour, flavour, texture and taste of the coated cashew kernel bits of 20 judges.

Table 4.6: Coating of different grades cashew kernels with cane sugar

Grade	Counts/5 g	Weight/kernel (mg)	% coating
BA	550	9.09	18.60
BBA	250	20.00	15.12
SDP	90	55.50	11.00
SWP	55	90.9	10.06
W 450	4.6	1086.9	7.88
W 320	3.46	1445.0	4.38
W 240	2.60	1923.0	4.17
W 210	2.13	2347.0	2.57
W 180	1.78	2808.0	2.93
W 150	1.44	3472.0	1.69
		CD (0.01)	2.79

Coating of cane sugar was done at 100°C for 5 min at 70% concentration. Coated kernels were extracted for 12 h at 10°C for estimation of sugars. Values are mean of three individual estimations.

Cashew kernel baby bits coated with 70% cane sugar and 0.1% vanillin are the most preferred. Acceptability of baby bits coated with clarified cashew apple juice (14.58) could be improved by incorporation of cane sugar at 70% concentration (12.58)

(Table 4.7). Defatting of cashew kernel baby bits with n-hexane helps in enhancing the extent of coating of cane sugar at 70% concentration. This would be helpful in developing fat free coated baby bits for calorie conscious consumers (Table 4.8).

Table 4.7: Sensory evaluation of cashew kernel baby bits coated with different coating agents.

Coating agent	% Coating	Mean cum. Hedonic score
Nil (uncoated baby bits)	—	14.85
70% Glucose	13.42	13.37
70% Fructose	12.45	12.56
70% Sucrose	13.38	13.06
70% Lactose	13.38	16.50
70% Honey	17.28	16.52
70% Cane sugar	11.14	13.84
70% Cane sugar with 0.1% vanillin	9.69	10.84
70% Cane sugar with 0.2% essential oil of cardamom	11.09	12.21
Clarified cashew apple juice	5.94	14.58
Clarified aroma stripped cashew apple juice	3.87	17.00
Clarified cashew apple juice containing 70% cane sugar	7.36	12.58
Clarified aroma stripped cashew apple juice containing 70% cane sugar	10.19	11.95
Cashew apple aroma distillate	—	14.85
Cashew apple aroma distillate containing 70% cane sugar	12.94	13.21
CD (0.01)		2.57

Mean cumulative hedonic score represents the cumulative hedonic score for colour, flavour, texture and taste of the coated bits of 20 judges. Per cent coating of sugar is the mean of two individual estimations.

Table 4.8: Coating of whole and defatted cashew kernel baby bits with cane sugar.

% Defatting	% Coating	Mean cum. Hedonic score
0	18.55	14.3
58	16.48	14.8
75	20.81	15.2
88	20.05	15.4
98	23.60	13.7
100	24.72	15.06

% coating values are mean of two individual estimations.

Mean cumulative hedonic score represents the cumulative hedonic score for colour, flavour, texture and taste of the coated bits of 20 judges.

4.1.3 Screening for variability in cashew apple from NCGB

A project for standardisation of protocol for cashew apple utilization has been initiated. Cashew apples of 47 accessions from 18 clusters in National Cashew Gene Bank are assessed for fresh weight, moisture content, juice content and pomace content. Weight of the cashew apple ranged from 27 to 185 g. Apples from NRC 120 had the highest weight of 185 g. Moisture content varied from 74.59% to 89.11%. Juice content varied from 58.82 to 79.08%. Highest juice content is noticed in NRC 97. Pomace obtained is in the range of 13.23 - 35.29%. Accession NRC 160 has the highest pomace content (Table 4.9).

4.1.4 Design development and performance evaluation of improved cashewnut sheller

An improved cashewnut sheller has been developed mainly to reduce the drudgery of operator working with it. This is basically a semi-mechanised sheller, deriving energy from pedal. Two cams provided in the design enable to hold and split open the conditioned nut in single operation. The unit can be operated in sitting posture which reduces the body strain to greater extent compared to the existing hand cum pedal operated sheller. The nut can be fed on either side of blade which improves the operational capacity. The screw adjusting mechanism incorporated on the sliding blade arm aids to shell the nuts of different size. The shelling unit costs approximately Rs. 1850.

Table 4.9: Screening for variability in cashew apple from NCGB.

Characters	Accession nos.
Weight (g)	
Small (0-50)	3, 9, 13, 14, 56, 79, 81, 84, 94, 95, 96, 101, 217
Medium (51-100)	1, 35, 59, 66, 72, 80, 93, 97, 100, 103, 109, 133, 137, 145, 159, 160, 176, 218, 228, 232, 233, 236, 241, 247
High (101-200)	18, 43, 107, 111, 112, 120, 127, 130, 140, 175
Juice yield	
Low (50-60%)	35, 160
Medium (61-70%)	3, 9, 13, 14, 18, 59, 66, 80, 100, 120, 137, 159, 176, 217, 241, 247
High (> 70%)	1, 43, 56, 72, 79, 81, 84, 93, 94, 95, 96, 97, 101, 103, 107, 109, 111, 112, 127, 130, 133, 140, 145, 175, 218, 228, 232, 233, 236
Pomace yield	
Low (10-20%)	1, 43, 79, 81, 93, 94, 95, 97, 109, 120, 133, 175, 228, 232
Medium (21-30%)	3, 9, 13, 14, 35, 56, 59, 66, 72, 80, 84, 96, 100, 101, 103, 107, 111, 112, 127, 130, 137, 140, 145, 159, 176, 218, 233, 236, 241, 247
High (31-40%)	18, 160, 217

5. TRANSFER OF TECHNOLOGY

5.1 Establishment of model cashew clonal garden

Based on the suitability for high density planting system ten plots were selected for laying out model cashew clonal gardens under Central Sector Scheme of DCCD, Cochin, in Puttur, Belthangady and Sullia taluks. Only three plots of high density planting could be established due to huge initial investment. Grafts of Vengurla-4, NDR-2-1 and Ullal-4 have been planted in these demonstration plots. With these, the number of demonstration plots established under this programme has risen to 81.

In order to monitor the demonstration plots and to assess the conditions of them regular visits were made and the demonstration farmers were advised on application of manures and fertilizers, training and pruning, soil and water conservation techniques and plant protection aspects. The demonstration plots were categorized into poor, medium / average and good plots according to the conditions of maintenance. Maintenance of most of the plots (90.48%) was under average to good.

5.2 Soil and water conservation and plant protection campaigns

A series of four campaigns were conducted in Dakshina Kannada (Karnataka) and Kollam districts (Kerala) to create awareness on the need for soil and water conservation and plant protection measures. These campaigns were conducted in collaboration with Sri Kshethra Dharmasthala

Rural Development Project, KJP Research Foundation and Sri Durga Charitable Society. The main objective was to educate farmers on conservation measures and to explain the important factors involved in the management of tea mosquito bug (TMB) and cashew stem and root borer (CSRB). The techniques of soil and water conservation and plant protection were explained to them with the help of charts and specimens which were specially designed for the purpose. Method of terracing, water conservation in plain lands and opening catch pits, method of coconut husk burial etc were explained to them. The farmers were educated on initial symptoms of tea mosquito bug damage and usage of different insecticides for its management. A total of 488 farmers participated in these campaigns.

5.3 Training Programme on cashew apple utilization for farm women

A training programme on utilization of cashew apple was organized at KVK, CPCRI, Kasaragod on cashew apple utilization for farm women. During the programme 62 farm



Demonstration of preparation of cashew apple products



women from Mangalore and Kasaragod districts sponsored by Department of Agriculture, Kerala and KVK, Manjeshwar, KAU participated. Preparation of cashew apple squash, chutney and jam was demonstrated to the farm women.

5.4 Participation in conference on “Uttara Kannada district Cashew Industry”

Scientists from this Research Centre

participated as resource persons in the day long conference organized by Cashew Processors in Uttara Kannada district on 9th March 2001 at Kumta. During the conference, farmers were advised on varieties of cashew, softwood grafting technique, improved cashew cultivation methods and pest management practices in cashew. A total of 500 farmers participated in the conference.

6. CONCLUDED PROJECTS

6.1: Root stock-scion interaction in cashew

Project Leader : Dr. K.R.M. Swamy
Project Associate : Dr. MG Nayak
Project No. : 2.9
Project Duration : 3 years (1998-2001)

6.1.1 Introduction

Cashew seedlings have been used as root stocks for production of grafts. Dwarfing cashew trees is a primary concern for cashew growers. Dwarfing mechanism is achieved by many horticultural practices such as, (i) selection of scion cultivars, (ii) use of dwarfing or size control root stocks, (iii) use of interstocks, (iv) use of growth regulators and (v) pruning. The most common method is the grafting of a size controlling root stock with a scion chosen for its fruiting potential. The concept of high density planting using dwarfing genotypes with compact canopy is gaining more acceptance in cashew cultivation. Hence, there is a need for trials with dwarfing root stocks. There is also a need to study the effect of plant growth retardants to reduce the tree size, so that high density plantations can be managed effectively. In many horticultural crops such as mango, Paclobutrazol, a growth retardant is being used to induce flowering in off year in the alternate year bearing varieties, to regulate fruiting, to improve the productivity and to reduce the vegetative growth. Hence, this project was initiated (i) to study the effect of root stocks on canopy growth of scion variety (ii) to study the effect of plant growth retardants on canopy growth in cashew. The results from this project will be helpful in understanding the root stock-scion interaction

in cashew and the role of root stocks in imparting dwarfing to the tall growing scion variety. This will facilitate the multiplication of dwarf clones required for high density planting. Alternatively, use of growth retardants such as Paclobutrazol may also be a solution to the problem of excessive growth in cashew.

6.1.2 Objectives

- * To study the influence of semi-tall root stocks on growth of scion variety.
- * To identify a root stock which can impart its semi-tall growth habit to the scion variety.
- * To study the effect of plant growth retardants such as paclobutrazol on regulation of tree size / canopy growth i.e. to induce dwarfing through chemical intervention.

6.1.3 Material and methods

A. Root stock studies:

Air layers were prepared from four semi-tall types (VTH 762/2, VTH 762/4, S 11/1 and S 11/2) identified at CPCRI, Regional Station Vittal and from one tall type (Selection-1) at NRCC Experimental Station, Shantigodu, during January - February 1996. Air layers of these root stocks (@12 no./root stock) were field planted during September 1996. Air layers (8 air layers/root stock type)



of different root stocks were *in situ* grafted with the scions of tall type (Selection-1) during July 1997, in order to study the influence of semi-tall root stocks on the growth of tall scions variety (Selection-1). Of the 40 *in situ* grafted air layers, 22 were successful. Plant height, trunk girth and canopy spread were recorded on the root stock types after one year and three months of planting and annually afterwards. Plant height, trunk girth - above and below graft joint, and canopy spread were recorded on the *in situ* grafts of Selection-1 with different root stock types after six months of *in situ* grafting and annually afterwards.

B. Induction of dwarfing through chemical intervention:

(i) Trials on paclobutrazol:-

In order to study the effect of paclobutrazol (PBZ), an antigibberellin biosynthate, on regulation of tree growth / canopy growth of cashew, two experiments were initiated in the scion bank at NRCC Experimental Station, Shantigodu. The trade name of chemical used was Cultar (25 % flowable concentration of paclobutrazol).

Experiment-I:- Soil application of PBZ

Variety : Vengurla-3
Spacing : 5m x 5m
Age of plants : 10 years
Experimental design : RBD with split plots
Number of replications : 4
Main plot (dosage g ai/plant) : 5
M₁ = 0.0 (control)
M₂ = 2.0
M₃ = 4.0
M₄ = 6.0
M₅ = 8.0

Sub plot (Method of application) : 2

- S₁ = Collar drenching
- S₂ = In circular ring (1.5 m away from the trunk)

No. of plants/main plot : 4

Time of application: Pre-flushing - September

The plant canopies were made uniform by pruning during the 1st week of August 1998. Treatments were imposed during September 1998, September 1999 and September 2000. PBZ at the required concentration was dissolved in 5 litres of water and applied in 10-15 cm deep trench and covered with soil. Observations on plant height increment, canopy spread increment, number of flushes/m², number of flowering laterals/m², number of non-flowering laterals/m², percentage of flowering laterals/m², length of flowering laterals, length of non-flowering laterals, and nut yield/plant, were recorded.

Experiment-II:- Foliar application of PBZ

Variety : VTH 30/4
Spacing : 5m x 5m
Age of plants : 10 years
Experimental design : RBD with split plots
Number of replications : 4
Main plot (dosage ppm) : 5
M₁ = 0 (control)
M₂ = 100
M₃ = 200
M₄ = 300
M₅ = 400

Sub plot (Method of application) : 2

- S₁ = Pre-flushing (September)
- S₂ = Post flushing (November)

No. of plants/main plot : 4

The plant canopies were made uniform by pruning during the 1st week of August 1998. Treatments were imposed in September / November during 1998 and 1999. PBZ at required concentration was sprayed on each plant to runoff (~ 2 l). Surfactant (microwet 1ml/l of spray solution) was also added. Observations on plant height increment, canopy spread increment, number of flushes/m², number of flowering laterals/m², number of non-flowering laterals/m², length of flowering laterals, length of non-flowering laterals, and nut yield/plant, were recorded.

(ii) Trial on chlormequat chloride

In order to study the effect of chlormequat chloride on regulation of tree growth / canopy growth of cashew, an observational trial was initiated in the scion bank at NRCC Experimental Station, Shantigodu. The trade name of the chemical used was Lihocin 50 AS (50% aqueous solution containing 500 g/l 2 chloroethyl-trimethyl ammonium chloride or chlormequat chloride).

Experiment-III:- Foliar application of chlormequat chloride

- Variety : Kanaka
- Spacing : 5m x 5m
- Age of plants : 3 years
- Treatments (dosage ppm) : 6
 - T₁ = 0 (control)
 - T₂ = 500
 - T₃ = 1000
 - T₄ = 1500
 - T₅ = 2000
 - T₆ = 2500

Number of applications : 2

Pre-flushing : September

Post flushing : November

Treatments of chlormequat chloride were imposed during September and November 1999 and 2000. Chemical at the required concentration was applied as foliar spray just before flushing in September and just after flushing in November and the plants were sprayed to runoff (~ 500 ml spray solution/plant). Surfactant (microwet 1ml/l) was also added. Observations on plant height increment, canopy spread increment, number of flushes/m², number of flowering laterals/m², number of non-flowering laterals/m², length of flowering laterals, length of non-flowering laterals were recorded.

6.2.4 Results and discussion

A. Root stock studies:

The mean plant height, trunk girth and canopy spread recorded have shown that the plants of Selection-1 were vigorous and taller as compared to the less vigorous and semitall root stocks (VTH 762/2, VTH 762/4, S 11/1 and S 11/2) (Fig.6.1, 6.2 and 6.3) (Table 6.1). The plants of S 11/1 had the lowest mean plant height, trunk girth and canopy spread, after 4 years and 3 months of planting in the field (Fig.6.1, 6.2 and 6.3). When compared with the tall type (Selection-1) (4.11 m) the plant height of semitall root stocks (S 11/1 and S 11/2) (2.12 and 2.17 m) after 4 years and 3 months of planting in the field was 47 per cent less than that of tall type.

The mean plant height, trunk girth and canopy spread recorded on the *in situ* grafts of selection-1 have shown that the growth of

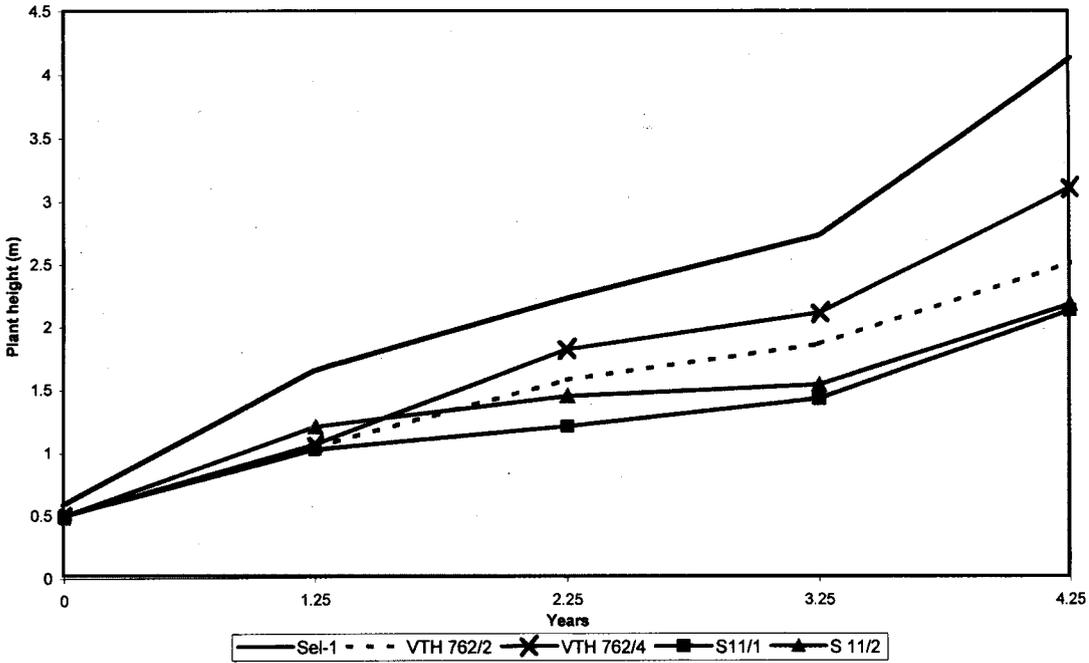


Fig. 6.1: Plant height of root stocks.

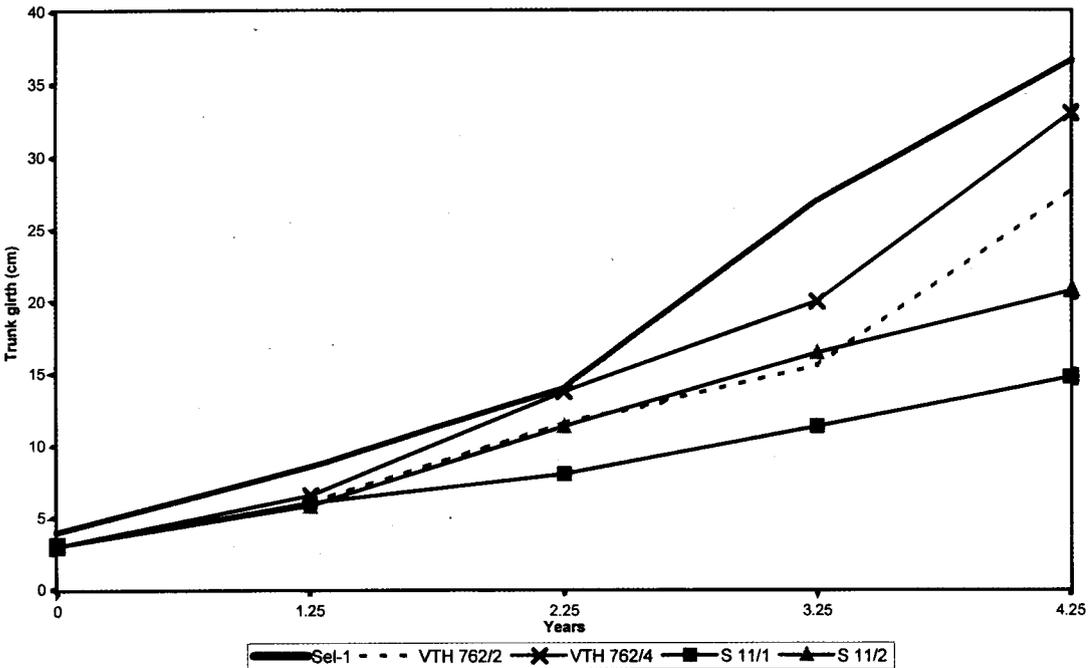


Fig. 6.2: Trunk girth of root stocks.

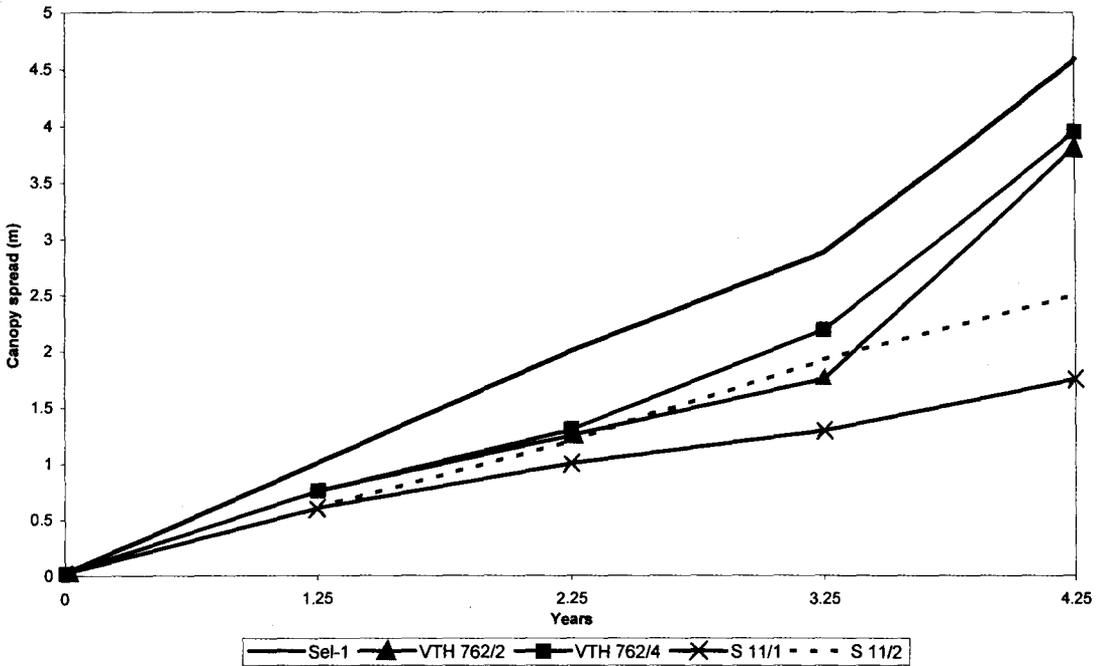


Fig. 6.3: Canopy spread of root stocks.

Table 6.1: Plant height of root stocks (after 4 years and 3 months of planting)

Root stocks	Plant height (m)	Plant height (% of tall type - Sel-1)
Tall type		
Selection-1	4.11	
Semi-tall types		
VTH 762/2	2.50	60.8
VTH 762/4	3.10	75.4
S 11/1	2.12	51.6
S 11/2	2.17	52.8

Table 6.2: Plant height of *in situ* grafts of Selection-1 (after 3¹/₂ years of *in situ* grafting).

<i>In situ</i> grafts (Root stock + Scion variety)	Plant height (m)	Plant height (% of tall type - Selection-1)	Plant height (% of semitall type - S11/1)
Selection-1 + Selection-1	4.05	98.5	191.0
VTH 762/2, + Selection-1	3.75	91.2	176.9
VTH 762/4 + Selection-1	3.93	95.6	185.4
S 11/1 + Selection-1	4.37	106.3	206.1
S 11/2 + Selection-1	3.76	91.5	177.3

the scion variety (Selection-1) was vigorous and tall irrespective of whether the root stock is a tall type (Selection-1) or semi-tall type (VTH 762/2, VTH 762/4, S 11/1 and S 11/2) (Fig.6.4, 6.5, 6.6 and 6.7) (Table 6.2).

When compared with the tall root stock (Selection-1), the plant height of *in situ* grafts of Selection-1 on tall (Selection-1) and semitall (VTH 762/2, VTH 762/4, S 11/1 and S 11/2) root stocks after 31/2 years of *in situ* grafting was almost same and the plant height ranged from 91.2 to 106.3% of tall root stock (Selection-1, 4.05 m). However, when compared with the semitall root stock (S 11/1, 4.37 m), the plant height of *in situ* grafts of Selection-1 on tall and semitall root stocks was higher and it ranged from 176.9 - 206.1% of semitall root stock (S 11/1) (Table 6.2). This

has indicated that the semitall root stocks evaluated in this experiment may not have any influence on the growth of tall scion variety (Selection-1). Hence, breeding of dwarf or semitall scion variety may be attempted instead of dwarf or semitall root stocks.

B. Induction of dwarfing through chemical intervention:

(i) Trials on paclobutrazol

Experiment-I Soil application of paclobutrazol

Significant differences among different concentration of PBZ were observed only for number of flushes/m², number of flowering laterals/m² and nut yield/plant during 1998-99 (Table 6.3). There was no significant

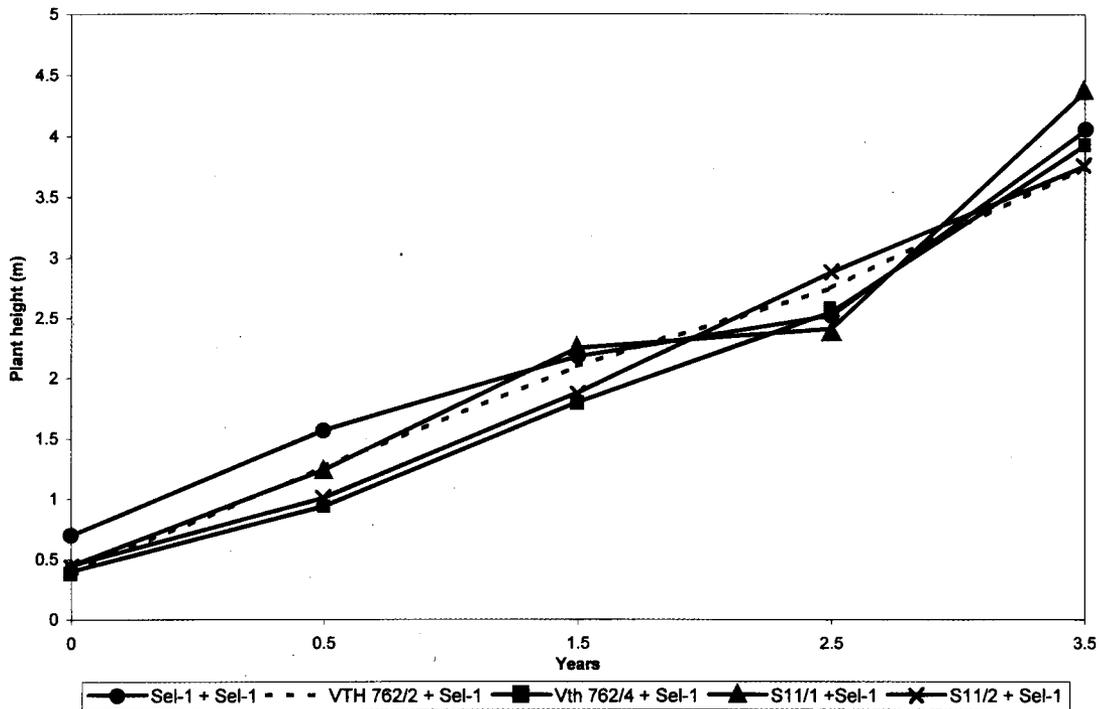


Fig. 6.4: Plant height of *in situ* grafts of Sel-1 on different root stocks.

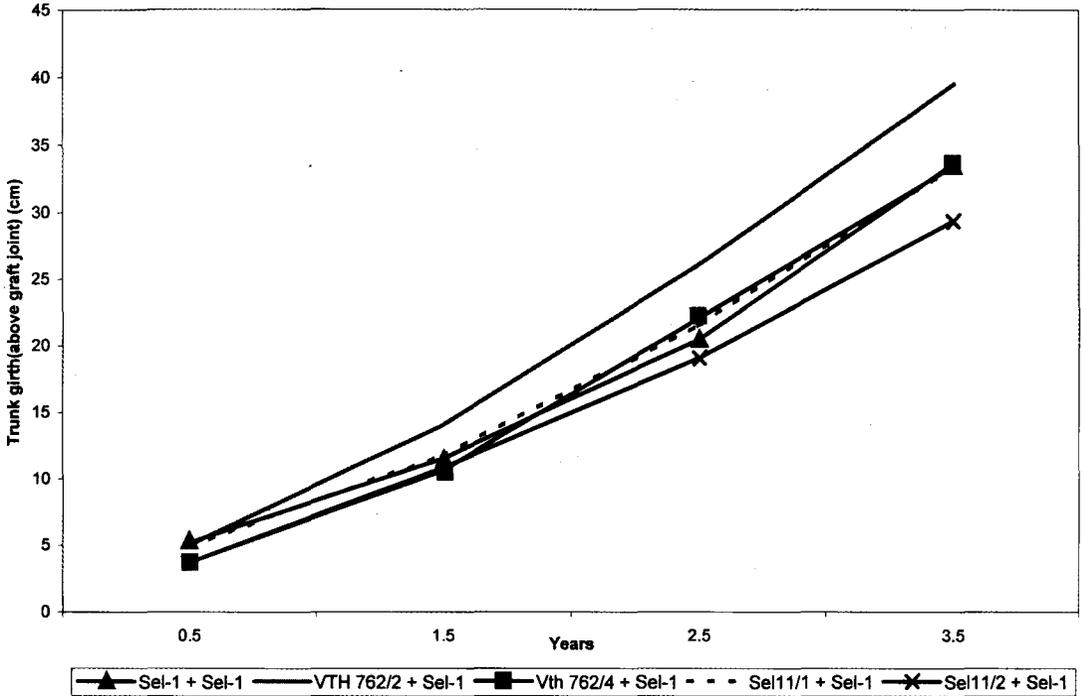


Fig. 6.5: Trunk girth (above graft joint) of *in situ* grafts of Sel-1 on different root stocks.

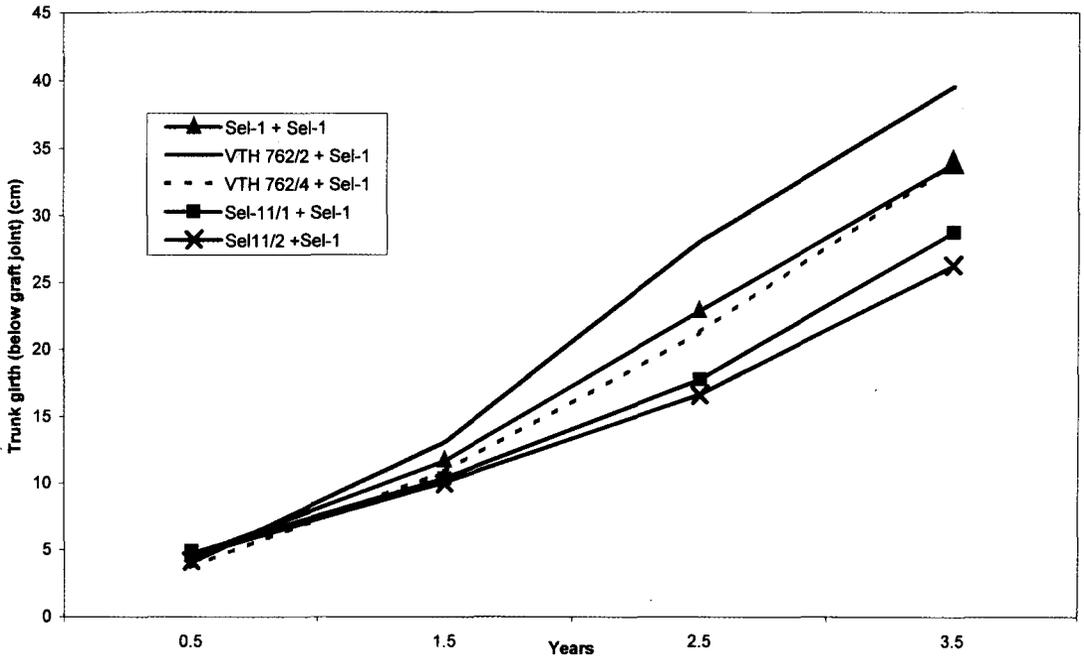


Fig. 6.6: Trunk girth (below graft joint) of *in situ* grafts of Sel-1 on different root stocks.

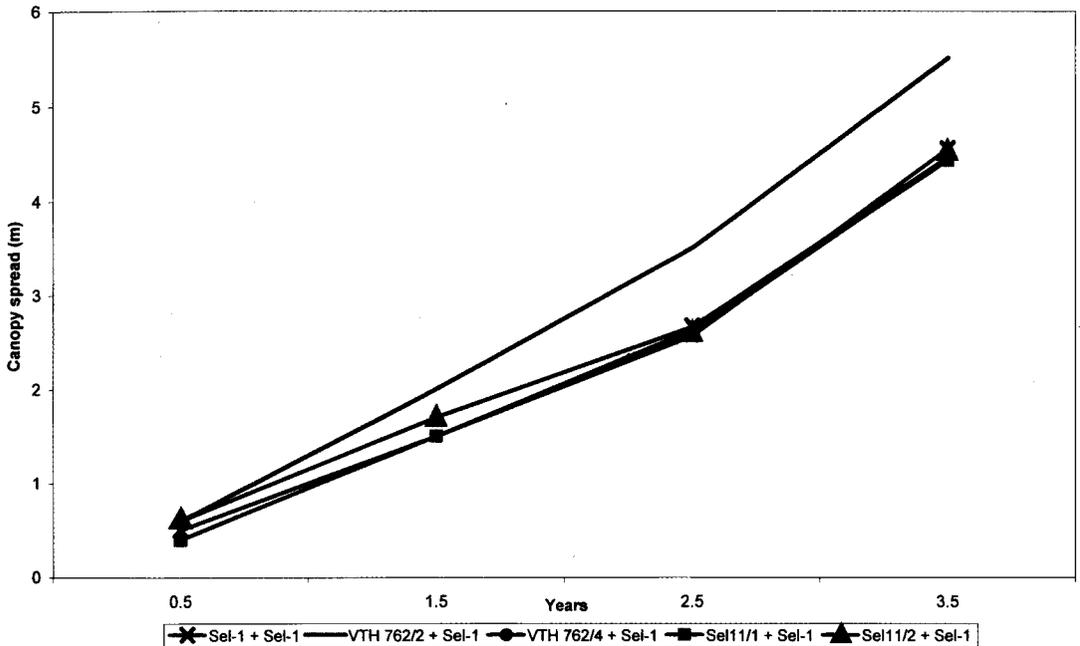


Fig. 6.7: Canopy spread of *in situ* grafts of Sel-1 on different root stocks.

difference between method of application (collar drenching and in circular ring).

Significant differences among different concentrations of PBZ were observed for plant height increment, canopy spread increment, length of flowering laterals, length of non-flowering laterals and nut yield/plant during 1999-2000 (Table 6.4). There was no significant differences between methods of application - collar drenching and circular ring method of application, for the above mentioned characters. Soil application of 8 g ai PBZ/plant was found to reduce the plant height increment (72.9%), canopy spread increment (65.0%), length of flowering laterals (64.5%), length of non-flowering laterals (75.0%), as compared to control (0 g ai/plant). This has also increased the nut

yield/plant (73.0%). Soil application of paclobutrazol (@8 g ai/plant) on three year old plants of Kanaka variety in the scion bank during September 1999 has also reduced the plant height increment (82.7%), canopy spread increment (66.7%), number of non-flowering laterals/m² (9.8), length of flowering laterals (71.3%), and length of non-flowering laterals (78.0%) and increased the number of flushes/m² and number of flowering laterals/m². In the treated plants rosetting of leaves and panicles emerging from the apical buds of previous season's shoots were also observed.

Significant differences among different doses of PBZ were observed for plant height increment, canopy spread increment, number of flushes/m², number of flowering

Table 6.3: Soil application of Paclobutrazol (1998-99)

	Plant height increment (m)	Canopy spread increment (m)	No. of flushes / m ²	No. of flowering laterals/m ²	No. of non-flowering laterals/m ²	Percentage flowering laterals /m ² *	Length of flowering laterals (cm)	Yield / plant (kg)
Factor-A								
M ₁ (0 g a.i./plant)	0.92	1.17	16.0	9.5	6.4	50.4	25.9	0.75
M ₂ (2 g a.i./plant)	0.87	1.13	13.6	8.0	5.6	50.1	22.9	0.78
M ₃ (4 g a.i./plant)	0.95	1.16	14.8	8.5	6.3	49.3	25.1	0.84
M ₄ (6 g a.i./plant)	0.83	1.15	18.6	11.4	7.3	51.5	23.7	1.00
M ₅ (8 g a.i./plant)	0.89	1.29	17.6	10.1	6.5	49.1	23.7	1.09
CD for A	NS	NS	3.0	2.2	NS	NS	NS	0.15
Factor-B								
S ₁ (collar drenching)	0.90	1.17	16.5	9.7	6.3	50.1	24.4	0.87
S ₂ (circular ring)	0.88	1.19	15.8	9.3	6.5	50.1	24.1	0.91
CD for B	NS	NS	NS	NS	NS	NS	NS	NS
CD for AB	NS	0.46	5.7	NS	NS	NS	NS	NS

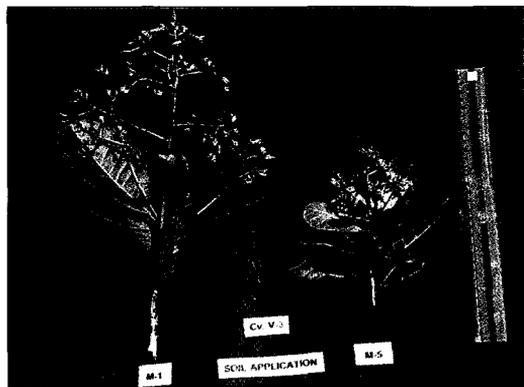
* Arcsin transformed values

Table 6.4: Soil application of Paclobutrazol (1999-2000)

	Plant height increment (m)	Canopy spread increment (m)	No. of flushes / m ²	No. of flowering laterals/ m ²	No. of non-flowering laterals/ m ²	Percentage flowering laterals /m ² *	Length of flowering laterals (cm)	Length of non-flowering laterals (cm)	Yield / plant (kg)
Factor-A									
M ₁ (0 g a.i./plant)	0.48	0.43	20.5	8.1	12.3	38.9	36.3	32.9	1.03
M ₂ (2 g a.i./plant)	0.60	0.54	22.7	10.1	12.7	41.8	31.3	28.3	1.10
M ₃ (4 g a.i./plant)	0.39	0.61	24.0	10.2	13.7	40.7	20.6	12.7	1.50
M ₄ (6 g a.i./plant)	0.32	0.24	24.3	11.8	12.5	44.2	16.7	9.9	1.83
M ₅ (8 g a.i./plant)	0.13	0.15	25.9	11.0	14.9	40.7	12.8	8.2	1.79
CD for A	0.29	0.20	NS	NS	NS	NS	4.2	4.9	0.25
Factor-B									
S ₁ (collar drenching)	0.31	0.43	23.9	10.1	13.8	40.6	24.0	18.5	1.44
S ₂ (circular ring)	0.46	0.41	23.9	10.4	10.7	41.3	23.2	18.3	1.46
CD for B	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD for AB	NS	NS	NS	NS	NS	NS	2.9	NS	NS

* Arcsin transformed values

laterals/m², percentage flowering laterals/m², length of flowering laterals and length of non-flowering laterals, during 2000-2001 (Table 6.5). There was no significant difference between collar drenching and circular ring method of application. Increased dosage of PBZ has reduced the plant height increment, canopy spread increment, length of flowering laterals, length of non-flowering laterals and increased the number of flushes/m², number of flowering laterals/m², percentage flowering laterals/m², as compared to control. Soil application of 6-8 g ai PBZ/plant was found to reduce the plant height increment (50.0 and 51.7%), canopy spread increment (58.9 and 57.5%), length of flowering laterals (38.9 and 55.3%), length of non-flowering laterals (69.0 and 74.4%) as compared to control. This has also increased the number of flushes/m² (38.6 and 64.2%), number of flowering laterals/m² (70.9 and 127.4%) and percentage flowering laterals/m² (13.7 and 22.8%) as compared to control. Hence soil application of 6-8 g ai PBZ/plant was found to be effective in regulating the tree growth in cashew.



Effect of soil application of PBZ at 8gai/plant on length of flowering lateral of Vengurla 3.

Experiment-II Foliar application of paclobutrazol

Significant differences among different concentrations of PBZ were observed only for number of flushes/m², and number of flowering laterals/m² (Table 6.6) during 1998-99. There was no significant difference between pre-flushing (September) and post flushing (November) applications. Significant differences among different concentrations of PBZ were observed only for length of flowering and non-flowering laterals (Table 6.7) during 1999-2000. There was no significant difference between pre-flushing (September) and post flushing (November) applications. Foliar application of PBZ was not found to be effective in containing the tree growth and canopy growth.

(ii) Trials on chlormequat chloride

Experiment-III Foliar application of chlormequat chloride

Foliar application of chlormequat chloride has reduced the plant height increment, canopy spread increment, length of flowering laterals, length of non-flowering laterals and increased the number of flushes/m², and number of flowering laterals/m², as compared to control during 1999-2000. Foliar application of 2500 ppm during preflushing (September) and post flushing (November) stage has reduced the plant height increment (36.2%), canopy spread increment (41.8%), length of flowering laterals (37.4%), length of non-flowering laterals (9.0%) as compared to control.

During 2000-2001 also, foliar application of chlormequat chloride (2500

Table 6.5: Soil application of Paclobutrazol (2000-2001)

	Plant height increment (m)	Canopy spread increment (m)	No. of flushes / m ²	No. of flowering laterals/ m ²	No. of non-flowering laterals/ m ²	Percentage flowering laterals /m ² *	Length of flowering laterals (cm)	Length of non-flowering laterals (cm)	Yield / plant (kg)
Factor-A									
M ₁ (0 g a.i./plant)	0.58	0.73	24.6	12.4	12.2	45.3	28.0	20.7	0.57
M ₂ (2 g a.i./plant)	0.56	0.57	24.5	14.2	10.2	49.4	26.5	17.4	0.33
M ₃ (4 g a.i./plant)	0.28	0.50	31.3	19.0	12.0	52.2	21.9	6.7	0.63
M ₄ (6 g a.i./plant)	0.29	0.30	34.1	21.2	13.6	52.1	17.1	6.4	1.22
M ₅ (8 g a.i./plant)	0.28	0.31	40.4	28.2	12.2	56.6	12.5	5.4	0.78
CD for A	0.13	0.23	4.6	3.9	NS	6.1	3.5	2.4	NS
Factor-B									
S ₁ (collar drenching)	0.40	0.47	31.9	19.4	12.7	50.3	21.2	11.5	0.82
S ₂ (circular ring)	0.39	0.49	30.1	18.6	11.4	52.0	21.2	11.2	0.59
CD for B	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD for AB	NS	NS	NS	NS	NS	NS	NS	NS	NS

* Arcsin transformed values

Table 6.6: Foliar application of Paclobutrazol (1998-99)

	Plant height increment (m)	Canopy spread increment (m)	No. of flushes / m ²	No. of flowering laterals/m ²	No. of non-flowering laterals/m ²	Percentage flowering laterals /m ² *	Length of flowering laterals (cm)	Yield / plant (kg)
Factor-A								
M ₁ (0 ppm)	0.89	1.15	18.1	12.6	5.3	56.5	27.6	2.64
M ₂ (100 ppm)	1.03	1.58	18.5	13.6	4.8	59.0	28.5	2.72
M ₃ (200 ppm)	0.76	1.39	18.2	13.1	5.2	58.0	30.6	2.28
M ₄ (300 ppm)	0.81	1.29	20.1	15.2	5.0	60.4	27.6	3.14
M ₅ (400 ppm)	1.00	1.40	22.0	17.1	5.0	61.8	26.1	3.04
CD for A	NS	NS	2.6	2.8	NS	NS	NS	NS
Factor-B								
S ₁ (September)	1.00	1.40	19.2	14.1	5.0	59.0	28.5	2.75
S ₂ (November)	0.80	1.32	19.5	14.5	5.1	59.6	27.6	2.78
CD for B	NS	NS	NS	NS	NS	NS	NS	NS
CD for AB	NS	NS	NS	NS	NS	NS	NS	NS

* Arcsin transformed values

Table 6.7: Foliar application of Paclobutrazol (1999-2000)

	Plant height increment (m)	Canopy spread increment (m)	No. of flushes / m ²	No. of flowering laterals/ m ²	No. of non-flowering laterals/ m ²	Percentage flowering laterals /m ² *	Length of flowering laterals (cm)	Length of non-flowering laterals (cm)	Yield / plant (kg)
Factor-A									
M ₁ (0 ppm)	0.53	0.36	21.3	14.0	7.3	54.1	27.6	26.6	2.89
M ₂ (100 ppm)	0.22	0.46	21.5	12.8	8.6	50.5	31.4	22.2	3.00
M ₃ (200 ppm)	0.27	0.38	19.6	11.6	7.9	50.3	24.8	30.7	2.92
M ₄ (300 ppm)	0.39	0.30	21.0	12.2	8.3	49.7	27.0	16.1	3.47
M ₅ (400 ppm)	0.23	0.52	19.8	11.9	7.8	50.8	25.3	17.3	3.18
CD for A	NS	NS	NS	NS	NS	NS	3.5	6.2	NS
Factor-B									
S ₁ (September)	0.31	0.32	20.5	12.5	7.8	51.3	26.3	22.7	3.21
S ₂ (November)	0.35	0.49	20.8	12.5	8.2	50.8	28.2	22.5	2.98
CD for B	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD for AB	NS	NS	NS	NS	NS	NS	NS	NS	NS

* Arcsin transformed values



ppm) during preflushing and post flushing stages has reduced the plant height increment (23.8%), canopy spread increment (25.3%), length of flowering laterals (32.2%), length of non-flowering laterals (37.8%) as compared to control.

6.2.5 Conclusion

A. Root stock studies:

- i) Selection-1 is a tall and vigorous growing root stock whereas, S 11/1 is a semitall and less vigorous root stock.
- ii) Compared with the tall root stock (Selection-1), the plant height of *in situ* grafts of Selection-1 on tall (Selection-1) and semitall (VTH 762/2, VTH 762/4, S 11/1 and S 11/2) root stocks was tall and vigorous like Selection-1. Trunk girth and canopy spread also exhibited similar trend.
- iii) Irrespective of the root stocks, growth of the tall scion variety

(Selection-1) was found to be tall and vigorous.

- iv) Semitall root stocks (VTH 762/2, VTH 762/4, S 11/1 and S 11/2) evaluated in the present experiment did not influence the growth of tall growing scion variety.

B. Induction of dwarfing through chemical intervention:

- i) Soil application of paclobutrazol @ 6-8 g ai/plant at preflushing stage (September) was found to be effective in regulating the tree and canopy growth in cashew.
- ii) Foliar application of paclobutrazol at concentration ranging from 0 to 400 ppm during pre-flushing (September) or post flushing (November) stage was not effective in regulating the tree and canopy growth.

6.2: Functional properties of defatted cashew kernel meal

Project Leader	: Dr. K.V. Nagaraja
Project No.	: 4.4
Project Duration	: 3 years (1998-2001)

6.2.1 Introduction

Cashew kernels from released varieties and pre-released varieties have been characterised for their biochemical constituents. Variation with respect to the biochemical constituents among the released varieties has been noticed. Processing of cashew nuts results in kernels of different grades such as wholes, splits, bits etc. Kernel baby bits fetch less compared to whole kernels. Functional properties such as water absorption capacity, oil absorption capacity, foaming capacity and emulsification capacity of defatted flour play an important role in developing food products from the flour. Extensive literature is available on studies of functional properties of different defatted flours. In order to develop value added products from cashew kernel baby bits, there is a need to generate basic data on functional properties of defatted cashew kernel flour.

6.2.2 Objectives

The objective of the project was to generate basic data on functional properties of cashew kernel baby bits for developing value added products.

6.2.3 Materials and methods

Different grades of cashew kernel such as wholes, small dessert pieces (SDP) and baby bits (BB) were procured from commercial processor. Soybean (JS 335) and almond (CITH sample) were procured from NRC Soybean, Indore and Central Institute for

Temperate Horticulture, Srinagar, respectively. Kernels were defatted with n-hexane at ambient temperature (27-30°C) over a period of 48 to 72 h and the defatted kernels were powdered and passed through 60 mesh. Defatted flour was used for all the studies. Water absorption capacity, oil absorption capacity, foaming capacity, emulsification capacity of defatted flours were determined as described in literature. Attempts were made to prepare milk and spread from cashew kernel baby bits. Cashew kernel baby bits was finely ground to form a paste (10 g/100 ml distilled water) and milk was reconstituted by suspending 10 g paste in 100 ml distilled water and decanted after 24 h storage at 6 to 10°C. The decanted milk was diluted to 200 ml and evaluated after addition of sugar (10%) and cocoa powder (25 mg %).

Spread from cashew kernel baby bits was prepared by blending 50 g of baby bits, 5 g of cane sugar and 10 ml of refined vegetable oil. Different flavours at 0.1 g/50 g baby bits and iodised salt at 0.1 to 0.5 g/50 g baby bits were added while preparing salted and flavoured spread. Different spreads thus prepared was evaluated by a panel of 15 judges for colour, flavour, spreadability, consistency and taste.

In order to develop cashew kernel oil based products, oil from cashew kernel baby bits, ground nuts, almond and sunflower seeds was extracted, refined and compared for keeping quality during storage at ambient temperature (27-30°C).

6.2.4 Results and Discussion

Studies on functional properties:

Functional properties of defatted cashew kernel flour prepared from different grades of processed cashew kernel, almond and soybean have been studied (Table 6.8). Water absorption capacity of defatted kernel flour obtained from different grades of cashew and almond was less compared to soybean. Lower water absorption of defatted flour of cashew kernel and almond indicates that the defatted flours of these are less hydrophilic in nature compared to soybean. As polar amino acids are the ones, which are responsible for binding of water molecules by

proteins, differences in water absorption capacity might suggest the variation in the polar amino acid composition of cashew, almond and soybean. Blending of defatted cashew kernel flour with either almond or soybean resulted in higher water absorption capacity thereby suggesting that defatted cashew kernel flour and soybean in the ratio of 1:1 could be useful in developing bakery products for which hydration property is required.

Oil absorption capacity of defatted cashew kernel flour (128.8%) was more than that of almond (115.5%) and soybean (96.8%). Blending of defatted cashew kernel

Table 6.8: Functional properties of different defatted flour

Defatted flour	Water absorption capacity %	Oil absorption capacity %	Least gelation conc. %	Foaming capacity (% volume increase)	Emulsification capacity	
					ml oil/g flour	ml oil/g protein
Whole cashew kernel	56.3	128.8	6.0	53.0	33.7	51.1
Cashew kernel - Baby bits	59.8	100.4	9.0	10.0	32.5	58.6
Cashew kernel - Small Dessert pieces	48.8	84.0	7.5	8.0	30.8	55.8
Almond kernel - Commercial sample	36.7	84.4	10.0	20.0	27.4	48.9
Almond kernel - CITH sample	46.8	115.5	6.0	42.0	32.5	63.0
Soybean JS335	100.2	96.8	15.0	50.0	23.0	34.7
Cashew (whole kernel) : Soybean (JS 335) (1:1)	73.7	119.3	9.0	37.0	64.4	140.4
Cashew (whole kernel) : Almond (CITH) (1:1)	114.3	138.5	9.0	40.0	68.9	168.6
Almond (CITH) : Soybean (JS 335) (1:1)	86.2	117.1	12.0	38.0	63.6	121.1
Cashew (whole kernel) : Almond : Soybean (1:1:1)	81.1	124.7	10.0	28.0	67.6	132.5
CD (1%)	13.87	17.01	-	10.09	7.41	19.13

Values are mean of three individual estimations

flour with either almond or soybean did not improve the oil absorption capacity of cashew kernel flour. Higher oil absorption capacity exhibited by defatted cashew kernel flour compared to either almond or soybean indicated the higher level of non-polar amino acids in cashew kernel protein compared to almond and soybean.

Defatted cashew kernel flour prepared from whole cashew kernels had better gelling properties with least gelation concentration of 6% compared to either almond or soybean. Mixing of cashew with either almond or soybean in the ratio of 1:1 had no effect on the least gelation concentration of composite flour mix (Table 6.8).

Foaming capacity of defatted flour of whole cashew kernel (53%) was higher compared to almond (42%) and soybean (50%). Foaming capacity of cashew kernel flour was reduced, when it was mixed either

with almond (40%) or soybean (28%). Thus mixing of defatted cashew kernel flour with either almond or soybean did not improve the foaming capacity.

Emulsification capacity of different defatted flours prepared from whole cashew kernel, small dessert pieces (SDP) and baby bits (BB) ranged from 30 to 32%. Soybean defatted flour exhibited lower emulsification capacity (22.7%). Emulsification capacity of cashew kernel flour could be improved by mixing with either almond or soybean in the ratio of 1:1. Improvement of defatted cashew flour by mixing with particularly soybean with respect to emulsification capacity could help in the preparation of milk from composite flour mix.

Absorption of different vegetable oils by defatted cashew, almond and soybean flours and their blends was studied (Table 6.9). Absorption of refined ground nut

Table 6.9: Oil absorption capacity of different defatted kernel flour (%).

Defatted kernel flour	Refined sunflower oil	Coconut oil	Palmolein oil
Whole cashew kernel	120.5	126.5	99.3
Cashew kernel - Baby bits	79.9	87.9	96.5
Cashew kernel - Small Dessert pieces	76.8	81.2	85.9
Almond kernel - Commercial sample	137.4	139.7	110.2
Almond kernel - CITH sample	152.4	155.2	120.5
Soybean JS335	91.9	96.9	88.6
Cashew (whole kernel) : Soybean (JS 335) (1:1)	108.9	109.2	103.2
Cashew (whole kernel) : Almond (CITH) (1:1)	124.4	149.7	126.8
Almond (CITH) : Soybean (JS 335) (1:1)	117.9	137.4	117.1
Cashew (whole kernel) : Almond : Soybean (1:1:1)	111.9	122.2	108.4
CD (1%)	10.01	6.93	9.92

Values are mean of three individual estimations

oil, sunflower oil, coconut oil and palmolein oil by defatted cashew kernel flour was higher compared to soybean. Mixing of cashew flour with soybean flour reduced the oil absorption capacity. Composite flour mix of cashew and soybean in the ratio of 1:1 had lower starch content (14.8%) compared to cashew. Mixing of cashew with almond slightly improved the oil absorption. Higher oil absorption by composite flour mix of cashew and almond could be due to other reasons which needs investigation.

Stability of the foam of defatted kernel flour of cashew (whole kernels), almond and soybean as a function of pH ranging from 2 to 10 was studied (Fig.6.8 to 6.10). At extreme pHs of 2 and 10, foam produced by defatted

cashew kernel flour was very unstable. Between pHs 3 to 9, foam produced by defatted cashew kernel flour was quite stable. In the case of almond, foam stability decreased with increase in pH from 3 to 10. Foam produced at pH 2.0 was quite stable. In the case of soybean also, foam produced at pHs ranging from 3 to 10 decreased. At pH 2, soybean defatted flour produced stable foam. Compared to almond and soybean, foam stability of cashew at pHs ranging from 3 to 9 was better. This could reflect on the solubility properties of defatted flour. Products could be developed from defatted cashew flour over a wide range of pH from 3 to 9. This could be an added advantage, while developing products for which foaming is required.

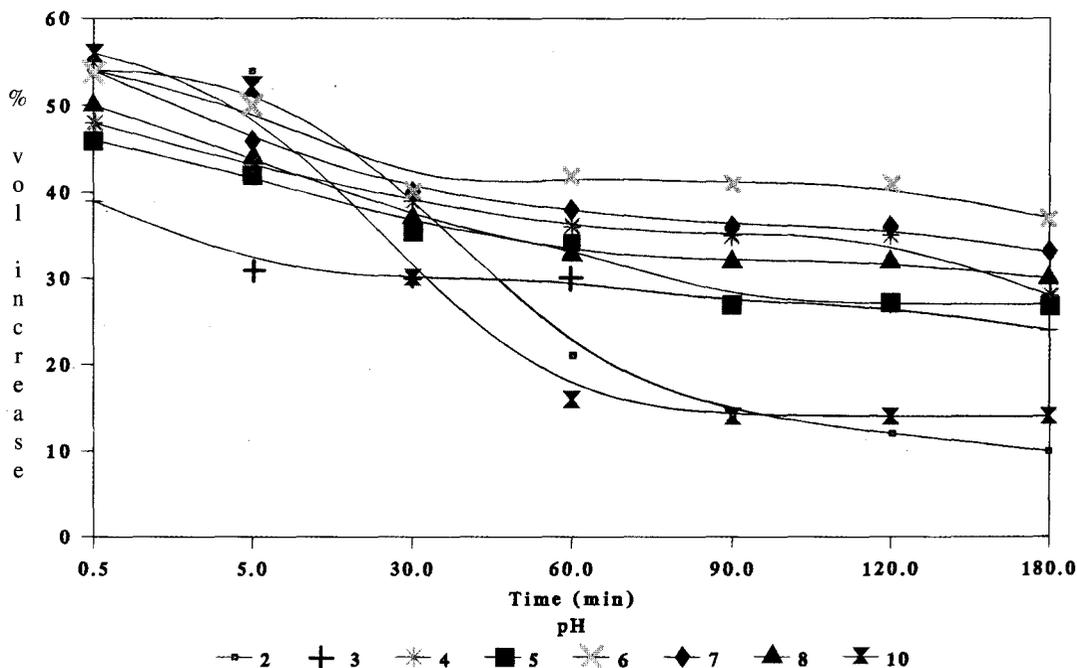


Fig. 6.8: Effect of pH on foam stability of defatted flour from whole cashew kernels.

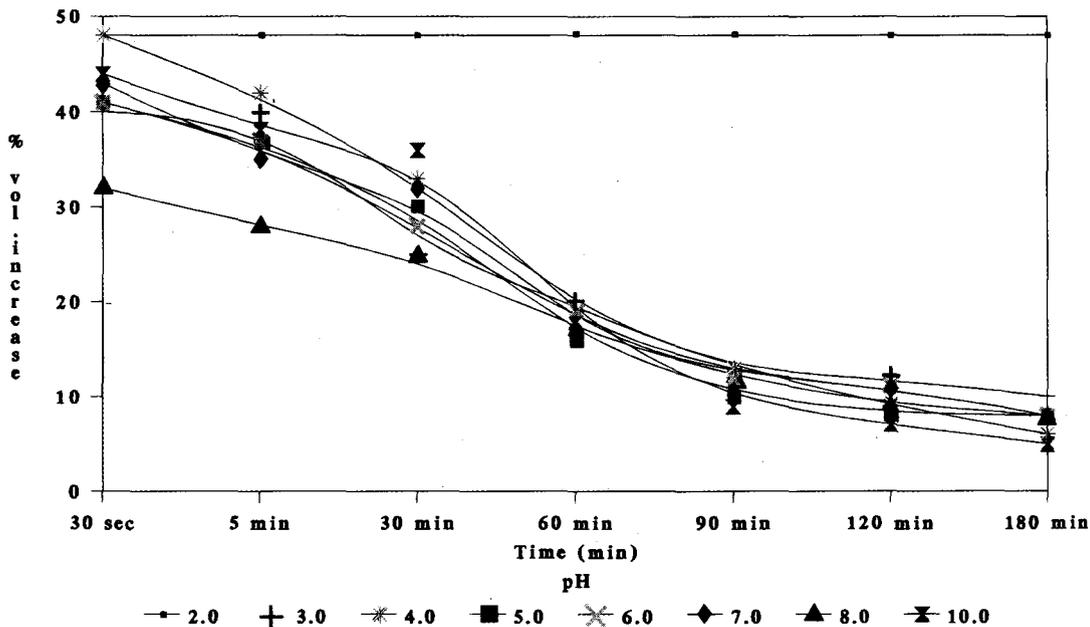


Fig. 6.9: Effect of pH on foam stability of defatted almond kernel flour (CITH sample)

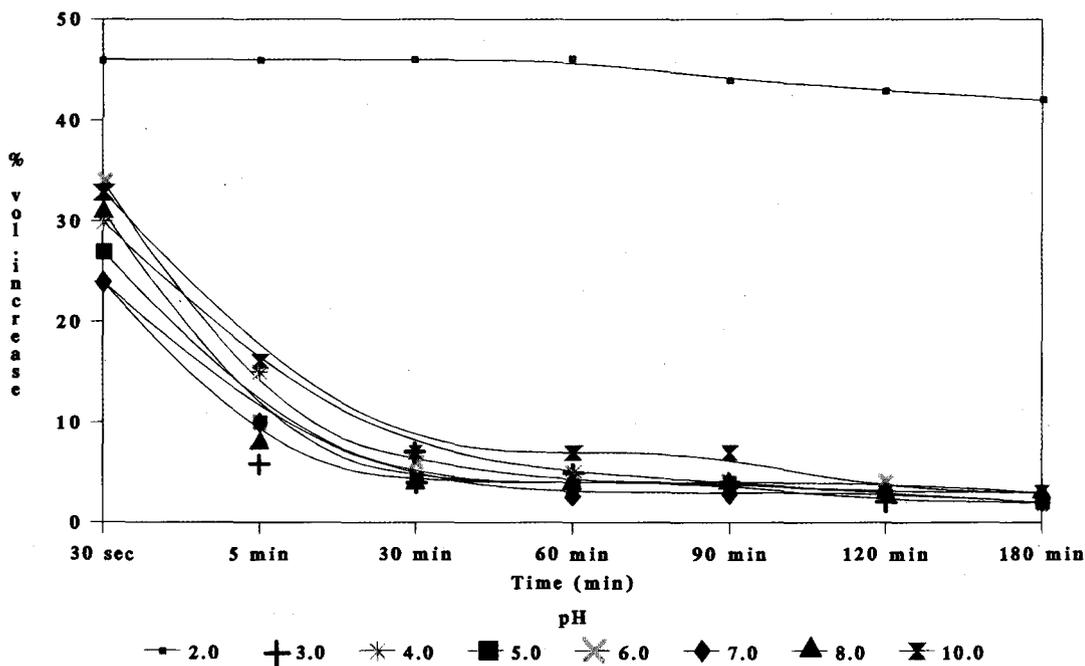


Fig. 6.10: Effect of pH on foam stability of soybean defatted flour (JS335)

Extractability of proteins from defatted flour as a function of pH was studied (Fig.6.11). Extractability of protein increased with pH in the case of almond (CITH), cashew kernel baby bits (BB) and small desert pieces (SDP). In the case of defatted kernel flour of cashew whole kernels, soy bean and almond (commercial sample) extractability at pH 2 and 10 was higher. Extractability of proteins between pH 3 and 9 did not vary much. Between pHs 3 and 9, a gradual increase in the extractability of proteins was observed. Differences observed in the foaming capacity and its stability at different pH could be due to differences observed in the extractability of proteins.

Extractability of proteins from defatted flour at different sodium chloride

concentration (0 to 0.6 M) was studied (Fig.6.12). Gradual increase in the extractability of protein was noticed. Although sodium chloride at different concentrations enhanced the extractability of proteins, it did not influence the foaming capacity of the defatted kernel flour.

Stability of the emulsion formed with double refined ground nut oil and different defatted kernel flour was studied (Fig.6.13). None of the emulsions formed was stable and considerable quantity of water got separated within few minutes after emulsion formation. Stable emulsion could not be produced from defatted cashew kernel flour and it may require addition of stabilisers for getting stable emulsions.

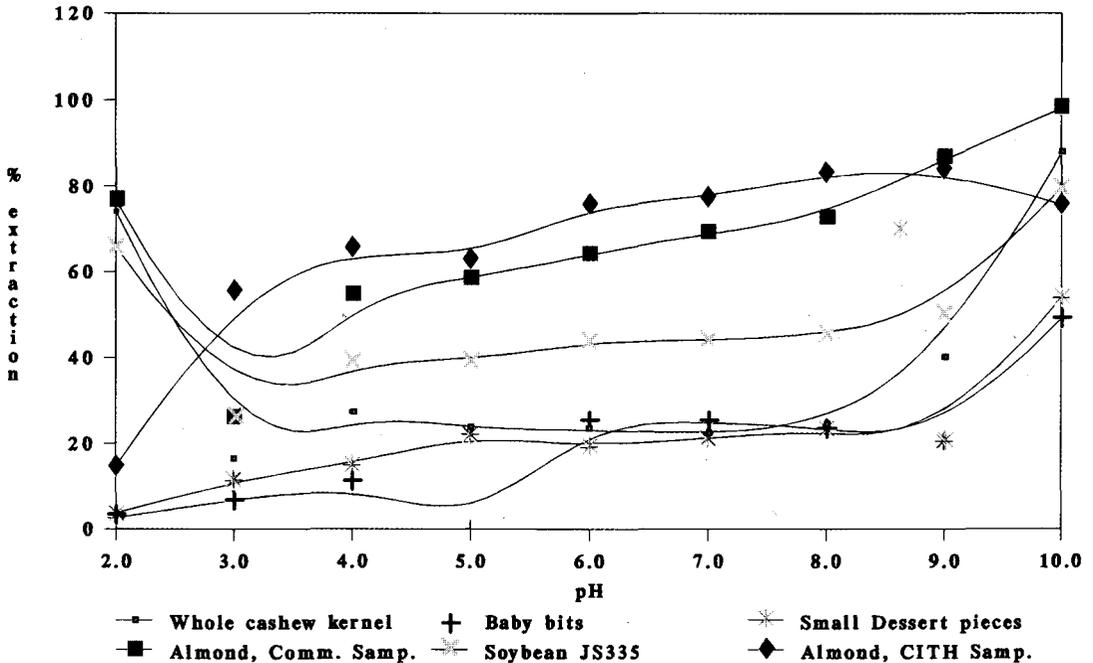


Fig. 6.11: Effect of pH on protein extractability.

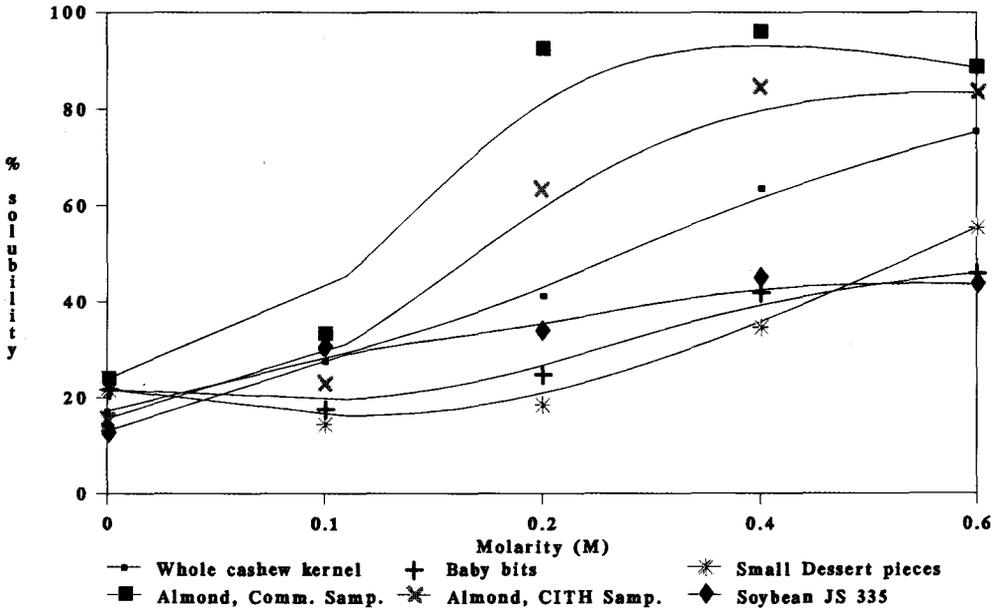


Fig. 6.12: Effect of NaCl concentration on protein extractability.

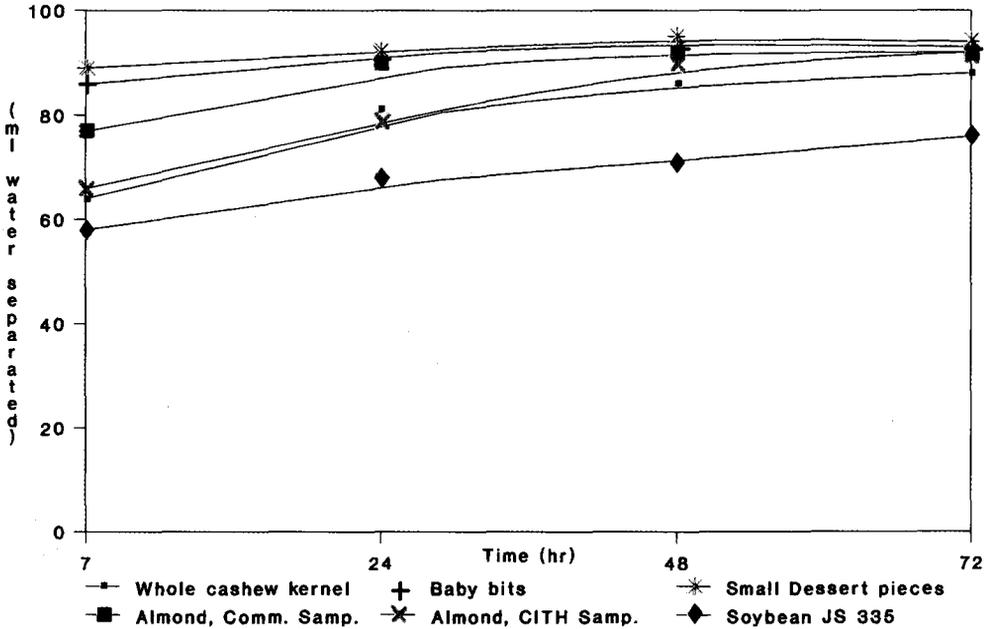


Fig. 6.13: Emulsion stability.

Preparation of milk

Cashew kernel baby bits were finely homogenized with distilled water to form a fine paste and stored at 6 to 10°C and < 0°C. Milk was constituted by blending 10 g paste with 100 ml water and decanted after 24 h storage at 6 to 10°C. Decanted milk was diluted to 200 ml. Protein and sugar in the milk was analysed (Table 6.10). Protein content in the milk did not change upto 34 days of storage. Sugar content, however,

decreased considerably after 25 days of storage. Cashew kernel paste after storage at 6 to 10°C for 7 days had fermented smell. Hence, organoleptic analysis of milk prepared from kernel paste stored at < 0°C only was done.

Sweetened milk (20 g/200 ml) and flavoured with cocoa powder (50 mg/200 ml) prepared from cashew kernel paste during storage at < 0°C was assessed for colour, flavour and taste by a panel of 15 judges (Table 6.11). Mean cumulative Hedonic score

Table 6.10: Protein and sugar content of milk prepared from kernel paste during storage at < 0°C .

Storage period (days)	A (mg/5 ml)		B (mg/5 ml)		C (mg/5 ml)		D (mg/5 ml)	
	Protein	Sugar	Protein	Sugar	Protein	Sugar	Protein	Sugar
0	20.3	11.8	22.0	10.6	22.4	20.2	23.3	21.0
7	20.2	15.9	20.5	15.1	21.2	31.7	23.8	31.5
14	20.3	18.2	24.7	19.5	24.4	21.9	24.7	21.9
25	23.3	18.0	23.8	18.9	25.5	30.8	23.1	34.4
34	23.5	5.3	24.9	5.7	21.2	8.5	20.0	10.1

Values are mean of three individual estimations

- A - Paste prepared from cashew baby bits alone.
- B - Paste prepared from cashew baby bits with sodium benzoate as a preservative.
- C - Paste prepared from cashew baby bits with cane sugar and sodium benzoate.
- D - Paste prepared from cashew baby bits with cane sugar.

Table 6.11: Mean Cumulative Hedonic scores for colour, flavour and taste of sweetened and cocoa flavoured milk prepared from kernel paste during storage at < 0°C

Storage period (days)	Mean Cumulative Hedonic score			
	A	B	C	D
0	9.1	9.9	10.4	10.0
7	11.1	10.2	9.9	10.2
14	10.8	10.2	11.6	12.1
25	9.5	9.58	10.3	10.2
34	9.2	9.50	9.8	10.4

A, B, C, D - Same as in Table 6.10

Mean cumulative hedonic score represents the cumulative hedonic score for colour, flavour, and taste of milk by 15 judges.

of the sweetened and flavoured milk did not change during storage indicating that cashew kernel paste could be stored at $< 0^{\circ}\text{C}$ upto 34 days without affecting the acceptability. Inclusion of sodium benzoate (12.5 mg/50 g), soya lecithin (1 g/50g), cane sugar (5 g/50 g) in the cashew kernel paste did not have any additional advantage.

Preparation of cashew kernel spread

Cashew kernel baby bits (50 g) were finely homogenized with cane sugar (5 g), iodised salt (0.1 and 0.5 g), vanillin (0.1 g) and vegetable oil (10 ml) to form a fine smooth paste. The spread thus prepared was stored at $< 0^{\circ}\text{C}$ for 24 h before assessed by a panel of 15 judges for colour, flavour, spreadability, consistency and taste (Table 6.12). Cardamom essential oil flavoured sweetened spread is the most preferred (13.7) while salted spread is least preferred (18.7). Inclusion of soy lecithin, an emulsifier and sodium benzoate, a

preservative, did not improve the acceptability of cashew spread.

Storage studies of cashew spread

Sweetened and vanillin flavoured spread prepared from cashew kernel baby bits was stored at 6 to 10°C and $< 0^{\circ}\text{C}$ for a period of 6 months and assessed at bimonthly intervals for iodine value, peroxide value and acid value (Table 6.13). Peroxides were not detected in the cashew spread. During storage at both temperatures iodine value and peroxide value increased. The fact that peroxides are not detected indicated that the cashew spread has not undergone any quality deterioration.

Sweetened and vanillin flavoured cashew spread was stored at $< 0^{\circ}\text{C}$ and $6-10^{\circ}\text{C}$ and assessed for acceptability at bi-monthly intervals for colour, flavour, spreadability, consistency and taste by a panel of 15 judges using a 9 point Hedonic scale (Table 6.14). Acceptability of cashew spread

Table 6.12: Sensory evaluation of cashew spread

	Mean Cumulative Hedonic Score
Cashew spread	18.2
Sweetened (5 g/50 g) cashew spread	15.4
Salted (0.5 g/50 g) cashew spread	18.7
Salted (0.1 g/50 g) cashew spread	17.0
Sweetened (5 g/50 g) and salted (0.1 g/50 g) cashew spread	15.5
Sweetened (5 g/50 g) vanillin (0.1 g/50 g) flavoured spread	15.1
Sweetened (5 g/50 g) cardamom (0.1 ml/50 g) flavoured spread	13.7
Sweetened (5 g/50 g) ginger (0.1 ml/50 g) flavoured spread	14.6
Sweetened (5 g/50 g) clove oil (0.1 ml/50 g) flavoured spread	16.2
Sweetened (5 g/50 g) cocoa (0.1 g/50 g) flavoured spread	17.8

Mean cumulative hedonic score represents the cumulative score for colour, flavour, spreadability, consistency and taste of spread by 15 judges.

Table 6.13: Keeping quality of cashew spread at low temperatures.

Storage temperature (°C)	Storage period (months)	Iodine value	Acid value
< 0	0	18.4	12.8
	2	29.4	10.8
	4	26.7	13.3
	6	28.9	14.6
6-10	0	18.4	12.8
	2	27.9	7.8
	4	38.6	15.2
	6	38.7	13.5

Values are mean of two individual estimations

Table 6.14: Organoleptic analysis of sweetened and vanillin flavoured cashew spread during storage at low temperatures.

Storage temperature (°C)	Storage period (months)	Mean cumulative hedonic score	
		Stored	Freshly prepared
< 0	0	-	16.3
	2	17.1	15.6
	4	18.2	17.1
	6	17.2	16.9
6-10	0	-	16.3
	2	17.0	15.6
	4	16.3	17.1
	6	16.5	16.9

Mean cumulative hedonic score represents the cumulative score for colour, flavour, spreadability, consistency and taste of spread by 15 judges.

was not affected during storage at low temperatures upto six months indicating that the spread could be stored at low temperatures (<0°C and 6-10°C) without quality deterioration. This is corroborated with the non detection of peroxides in the spread during storage at low temperatures.

Storage studies of cashew kernel oil

Oil from cashew kernel baby bits, almond, ground nut and sunflower obtained from local market was extracted with n-hexane and the oil thus extracted was refined by alkali and solvent treatment. Refined oils were assessed for their properties during

storage at ambient temperature. (Table 6.15). Cashew kernel oil is quite stable upto six months as iodine value and acid value did not increase during storage. The increase in acid value during storage of ground nut oil, sunflower oil indicate that cashew kernel oil has better storage stability.

6.1.5 Conclusion

Functional properties of defatted cashew kernel flour could be improved by mixing with soybean for its water absorption capacity and emulsification capacity. Defatted cashew kernel flour in combination with soybean could be used in developing

bakery products where hydration properties is required. Further, cashew offers an additional advantage of producing stable foam over wide pH range from 3 to 9. With its low least gelation concentration of 6%, it could be used in developing products where gelling is required. Milk and spread could be prepared from cashew kernel baby bits. Cashew kernel spread could be stored at low temperature (<0°C and 6 to 10°C) for a period of six months without quality deterioration. Oil extracted from cashew kernel baby bits could be stored at ambient temperature upto six months without affecting the quality.

Table 6.15: Keeping quality of refined oils at ambient temperature (27-30°C)

Storage period (months)	Oils	Iodine value	Acid value
0	Cashew	84.3	0
	Almond	88.0	0
	Ground nut	84.2	0
	Sunflower	103.9	0.25
2	Cashew	87.2	0.43
	Almond	82.8	-
	Ground nut	94.2	1.43
	Sunflower	101.4	2.12
4	Cashew	85.3	0.58
	Almond	86.5	2.99
	Ground nut	88.3	2.40
	Sunflower	91.7	8.60
6	Cashew	88.9	0.96
	Almond	94.6	2.78
	Ground nut	90.3	4.18
	Sunflower	51.6	38.24

Values are mean of two individual estimations

7. EDUCATION AND TRAINING

Training

A training on vegetative propagation of cashew was conducted on 7th and 8th September 2000 at NRCC for staff members of development departments and progressive farmers in which trainees were made to acquire the skill of softwood grafting. Trainees from Karnataka, Kerala, Madhya Pradesh and Nagaland participated in this programme.

In the training programme on cashew production technology arranged on 16-18 January 2001, trainees sponsored by Bharatiya

Agro Industries Foundation, Gujarat, Plantation Corporation of Kerala, Kasaragod and Orissa State Cashew Development Corporation, Bhubaneswar participated. Technologies developed on all aspects of cashew production were explained to the trainees.

In the training programme on cashew apple utilization held at KVK, Kasaragod, 62 farm women from Dakshina Kannada and Kasaragod district participated. Methods of preparation of cashew apple squash, chutney and jam were demonstrated.

8. LINKAGES / COLLABORATION

- In collaboration with PDBC, Bangalore, EAG studies with CSRB were undertaken. Volatiles and extracts from both healthy bark and frass have been analysed by GCMS.
- DNA finger printing of the accessions from NCGB has been taken up in collaboration with UAS, Bangalore.
- Soil and water conservation and plant protection campaigns were conducted in collaboration with Sri Kshetra Dharmasthala Rural Foundation, Dharmasthala, KJP foundation Thiruvananthapuram and Sri Durga Charitable Society, Keyyur. DCCD, Kochi gave financial support for these campaigns.
- Training programme on utilization of cashew apple was organized in collaboration with KVK of CPCRI, Kasaragod, Department of Agriculture, Kerala and CFTRI, Regional Centre, Mangalore.
- Eighty one demonstration plots laid out with financial support of DCCD, Kochi were monitored.



9. AICRP CENTRES

Headquarters

Project Coordinator(Cashew)
National Research Centre for Cashew
Puttur 574 202, DK, Karnataka.
Phone No.08251-21530 (0); 20992(R).
Fax No. 08251-21590

University centres

1. Cashew Research Station
(Acharya NG Ranga Agricultural University.)
Bapatla 522 101, Guntur Dist.,
Andhra Pradesh.
Phone No.(086432) - 24052, 25098.
2. Cashew Research Station
Department of Agriculture
(Orissa University of Agriculture and Technology)
Bhubaneswar 751 003, Orissa.
Phone No. (0674) - 402669.
3. Agricultural Research Station
(University of Agricultural Sciences)
Chintamani 563 125, Kolar District,
Karnataka.
Phone No. (08154) - 52118, 50420.
4. Zonal Agricultural Research Station
(Indira Gandhi Krishi Vishwa Vidyalaya)
Jagdalpur 494 005,Kumharawand, Bastar District,
Chattisgarh.
Phone No. (07782) - 36301, 23360.



5. Regional Research Station
(Bidhan Chandra Krishi Viswa Vidyalaya)
Jhargram Farm, PO Jhargram
721 507, Midnapore District,
West Bengal.
Phone No. (03221) - 55593.

6. Cashew Research Station
(Kerala Agricultural University)
Madakkathara 680656, Thrissur Dist.
Kerala.
Phone No. (0487) - 370339.

7. Regional Agricultural Research Station
(Kerala Agricultural University),
Pilicode 671 353,
Kasaragod District, Kerala.
Phone No. (0499) - 760554, 760 632.

8. Regional Fruit Research Station
(Konkan Krishi Vidyapeeth)
Vengurle 416 516, Sindhudurg District,
Maharashtra
Phone No. (02366) - 62234

9. Regional Research Station
(Tamil Nadu Agricultural University)
Vridhachalam 606 001, South Arcot District,
Tamil Nadu.
Phone No. (04143) - 60231, 60412

10. GENERAL INFORMATION

10.1 List of Publications

10.1.1 Research/Popular Publications

Balasubramanian, D. 2000. Status report on cashew processing industries of Dakshina Kannada. *The Cashew*. 14(2):12-25.

Balasubramanian, D. 2000. Cashew processing in Palasa of Andhra Pradesh - A case study. *The Cashew*. 14(4):7-17.

Balasubramanian, D. 2001. Physical properties of raw cashew nuts. *Journal of Agricultural Engineering Research* (In press).

Bhaskara Rao, E.V.V. and Nagaraja, K.V. 2000. Status Report on Cashew. In: Souvenir -International Conference on Plantation Crops. PLACROSYM-XIV, 12-15 Dec. Hydrabd.

Nagaraja, K.V. 2000. Biochemcial composition of cashew kernel testa. *J. Food. Sci. and Technol.* 37(5):555-556.

Nagaraja, K.V. 2001. Functional properties of defatted cashew kernel flour. *J. Food. Sci. and Technol.* 38(4):321-325.

Nagaraja, K.V., Bhasakara Rao, E.V.V. 2000. Cashew Research in India - Achievements and Future Strategies. Silver Jubilee Souvenir, UAS, Bangalore, ARS, Chintamani, 15-22.

Sundararaju, D. 1999. Screening cashew accessions against tea mosquito. *The Cashew*. 13(4):20-26.

Sundararaju, D. 2000. Insects associated with extrafloral nectaries of cashew leaves. *J. Plantn. Crops*. 28:175-178.

Sundararaju, D. 2000. Foraging behaviour of pollinators on cashew. *The Cashew*. 14(4):20-26.

Sreenath Dixit and E.V.V. Bhaskara Rao. 2000. Kisan Goshti - An interface with cashew farmers. *The Cashew*. 14(1):24-31.

10.1.2 Papers presented in Symposia / Workshop / Seminar

EVV Bhaskara Rao, 2000. Technological Options available for Improved Production from New Cashew Orchards. In: State Level Seminar on Cashew, organised by Orissa State Cashew Development Corporation Limited, Bhubaneswar, 30-31 May 2001. 8pp.

Swamy, K.R.M. and Bhaskara Rao, E.V.V. 2000. Raising of cashew orchards with grafts and development support required for making them productive. In: Selected Articles - Sate Level Seminar on Cashew. Orissa State Cashew Development Corporation Limited, Bhubaneswar, 30-31 May 2000. pp.47-56.

Raviprasad, T.N. and Bhat, P.S. 2000. Olfactometer and free choice evaluation of cashew plant parts and attractants to cashew stem and root borer : *Plocaederus ferruginues* (Coleoptera : Cerambycidae) In: International Conference on Plantation Crops - PLACROSYM-XIV, Hyderabad, 12-15 Dec. 2000. Abstract No. 0-21, pp.16-17.

Raviprasad. T.N., Sundararaju, D. and Bhat, P.S. 2000. Effect of botanicals against *Helopeltis antonii* Sing. (Miridae : Hemiptera) infesting cashew. In: International Conference on Plantation Crops - PLACROSYM-XIV, Hyderabad, 12-15 Dec. 2000. Abstract No. P-96. p.80.

Swamy, K.R.M., Bhat, M.G. and Bhasakara Rao, E.V.V. 2000. Developing a core collection of cashew. In: International Conference on Plantation Crops - PLACROSYM-XIV, Hyderabad, 12-15 Dec. 2000. Abstract No. P-18. p.38.

Anik Luke Dhanaraj, Bhaskara Rao, E.V.V., Swamy, K.R.M., Theertha Prasad, D. and Suresh N. Sondur. 2001. Use of RAPD markers in diversity analysis and germplasm management in cashew (*Anacardium occidentale* L.). IX Plant and Animal Genome Conference, 13-17 January 2001, San Diego, California, USA.

.3 Book / Chapters

Abdul Salam, M. and E.V.V. Bhaskara Rao. 2001. Cashew - Varietal Wealth of India. Directorate of DCCD, Government of India, Ministry of Agriculture, Cochin. 682011, India (I Edition). Pp.101.

Thimmappaiah, Shirly R.A. and Iyer, R.D. 2000. Cashew. In: Biotechnology of Horticultural Crops (Ed: V.A. Parthasarathy et al.). NP Sales Pvt. Ltd. Kolkata. Vol.I. pp.609-629.

Swamy, K.R.M., Bhaskara Rao, E.V.V. and Bhat, M.G. 2000. Catalogue of Minimum Descriptors of Cashew (*Anacardium occidentale* L.) Germplasm Accessions-III. National Research Centre for Cashew, Puttur-574202, October 2000. pp.54.

.4 Technical Reports / Bulletins / Compendia

National Research Centre for Cashew. 2000. Research Highlights 2000-2001. Puttur, Karnataka. 27 pp.

All India Coordinated Research Project on Cashew. 2000. Annual Report 1999-2000. National Research Centre for Cashew, Puttur, Karnataka. 99 pp.

National Research Centre for Cashew. 2000. Annual Report 1999-2000. Puttur, Karnataka. 136 pp.

National Research Centre for Cashew. 2000. Cashew News. Newsletter No.1. Vol.5. Puttur, Karnataka.

National Research Centre for Cashew. 2000. Cashew News. Newsletter No.2. Vol.5. Puttur, Karnataka.

10.2 List of Ongoing Research Projects

Project No.	Project Title	Project leader/associate
CROP IMPROVEMENT		
1.1	Collection, conservation, cataloguing and evaluation of cashew germplasm	KRM Swamy MG Bhat PS Bhat KV Nagaraja
Ad-hoc Scheme	Network programme on collection of cashew germplasm from east coast and west coast regions of India	MG Bhat Evv Bhaskara Rao KRM Swamy D Manjunath H Yajnesh
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
2.7	Integrated nutrient management for sustainable production of cashew	N Yadukumar
2.8	Efficacy of soil and water conservation with organic and inorganic manuring in cashew garden grown in slopy areas	N Yadukumar
2.9	Root stock scion interaction in cashew	KRM Swamy MG Nayak

Project No.	Project Title	Project leader/associate
CROP PROTECTION		
3.4	Integrated pest management of cashew stem and root borer (CSRB)	TN Raviprasad PS Bhat D Sundararaju
3.5	Integrated pest mangement of tea mosquutio bug (TMB)	D Sundararaju PS Bhat TN Raviprasad
3.6	Studies on determination of insecticide residues in cashew kernels.	PS Bhat TN Raviprasad
POST HARVEST TECHNOLOGY		
4.3	Developing modified cashewnut sheller	D Balasubramanian
4.4	Functional properties of defatted cashew kernel meal	KV Nagaraja
Ad-hoc Scheme	Value addition in cashew	KV Nagaraja MS Mahesh (upto 4.11.2000)
4.5	Standardisation of protocol for cashew apple utilization.	S Bhuvaneshwari KV Nagaraja
5. TRANSFER OF TECHNOLOGY		
5.1	Research cum demonstration plots	R. Venkattakumar

10.3 Important Meetings and Significant Decisions.

10.3.1 Research Advisory Committee

- Dr. K.V. Ahamed Bavappa, FAO Consultant
Karooth Villa, P.O. Kappur,
Kumaranellur 679 552
Palakkad District, Kerala
- Chairman



2. Dr. R.T. Gunjate Member
Reliance Petroleum Limited
Horticulture Department
E.O.2, Township,
Motikhavadi 361 140
Jamnagar District (Gujarat)
3. Prof. A. Regupathy Member
Professor of Entomology
AC & RI, Coimbatore 641 003
4. Mr. P.P. Balasubramanian Member
Director
Directorate of Cashewnut and Cocoa Development
Govt. of India
Ministry of Agriculture, (Dept. of Agri. Cooperation)
8th Floor, Kera Bhavan, Cochin 682 011, Kerala
5. Dr. B.R. Hedge Member
(Retired Director of Research)
347, 10th Main, 7th Cross, NTI Layout
Vidyaranyaपुरa
Bangalore 560 097
6. Mr. Md. Alai Baig (Upto Nov. 2000) Member
Village Garare, Via Jale
Dist. Darbhanga, Bihar
7. Mr. Shashikant Chaudhury (Upto Nov. 2000) Member
Village Brahmpur, PO Ratanpur
Dist. Darbhanga, Bihar 847 307
8. Dr. R.N. Pal Member
Deputy Director General (Hort)
Indian Council of Agricultural Research
Krishi Bhavan
New Delhi 110 001
9. Dr. E.V.V. Bhaskara Rao Member
Director
NRC-Cashew, Puttur 574 202

10. Dr. K.R.M. Swamy
Principal Scientist (Hort.)
NRC-Cashew, Puttur 574 202
DK, Karnataka

Member-Secretary

Significant Decisions:

- Wherever a cluster consists of 1 to 2 accessions, area from where this has been originally collected is to be resurveyed to ensure that adequate variability is conserved.
- For isozyme analysis Mrs. Shirly Raichal Anil will use the core collections in NCGB. She will extract DNA and take to UAS Bangalore for DNA finger printing. Isozyme studies in cashew is to be completed in three years.
- Selfing of dwarf type (Taliparamba-1) available at RARS, Pilicode is to be done during flowering season of 2001. Research Associate may be sent to Pilicode for a week by Dr. M.G. Bhat.
- Dr. K.V. Nagaraja may study the variability for flavonoids, tannin, sugar etc in cashew apples and assess the quality of apples required for candy.
- After 5th year of evaluation promising F1 hybrids may be multiplied. F1 hybrids are to be evaluated under uniform conditions.
- As the cashew processing industry is interested in recovery of wholes, the required information for all the cashew varieties may be tabulated and given by Dr. K.V. Nagaraja (variety, shelling percentage, recovery of wholes, number of wholes per pound)
- Efforts may be made to standardize micrografting technique.
- Instead of square system of planting, hedge row system of planting with closer spacing within the row is to be followed in cashew.
- In high density planting, thinning of plants is required instead of detopping as it attracts CSRB.
- In high density system of planting yield/unit area/unit time is to be reported instead of yield per plant.
- Foliar application of paclobutrazol may be discontinued as the soil application is very effective.
- Run-off taking place in different treatments may be documented at NRCC/KCDC.

- Instead of designing traps for CSRB, the existing traps for red palm weevil or rhinoceros beetle may be modified and used.
- For fixing the age of CSRB grubs the size of the head capsule may be recorded and compared with prothoracic shield width.
- Prediction model is to be worked out for forecasting TMB outbreak well in advance and for suggesting control measures to farmers. Dr. D. Sundararaju may visit, TNAU, Coimbatore along with weather data of NRCC and discuss with Entomology Scientists.
- Residue levels in the samples collected from farm gate / market may be documented.
- Synthetic colours should not be used as these are banned for usage in confectionary. Only permitted colours for confectionary are to be used.
- In addition to blending cashew apple fibre with baby food, it should also be mixed with ragi flour.
- Package of practices for high density system of planting may be prepared and got printed soon.

10.3.2 Institute Management Committee (1997-2000)

1.	Director NRCC Puttur	Chairman
2.	Joint Director of Horticulture (P.C.) Directorate of Horticulture Govt. of Karnataka Lalbagh, Bangalore 560 004	Member
3.	Special Secretary of Agriculture Govt. of Kerala Thiruvananthapuram 695 001	Member
4.	Head, Division of Horticulture College of Agriculture UAS, GKVK, Bangalore 560 065	Member
5.	Asst. Director General (PC) ICAR, Krishi Bhavan New Delhi 110 001	Member

6.	Mr. Md. Alai Baig (Upto Nov. 2000) Village Garare, Via Jale Dist. Darbhanga, Bihar	Member
7.	Sri. Shashikant Chaudhury (Upto Nov. 2000) Village Brahmpur, PO Ratanpur Dist. Darbhanga, Bihar 847 307	Member
8.	Dr. KRM Swamy Pr. Scientist, NRCC, Puttur	Member
9.	Dr. MG. Bhat Sr. Scientist, NRCC, Puttur	Member
10.	Dr. TN Raviprasad Scientist (SS), NRCC, Puttur	Member
11.	Mrs. Shirly Raichal Anil Scientist, NRCC, Puttur	Member
12.	Sr. Finance & Accounts Officer CPCRI Kasaragod	Member
13.	Sri.K.Sanjeeva Asst. Administrative Officer NRCC, Puttur	Member-Secretary

The committee met twice on 20.11.2000 and 20.3.2001 during the year and assessed the progress of research projects and ad-hoc projects. It accorded approval for the purchase of equipments.

10.3.3 Staff Research Council Meeting

Thirteenth Staff Research Council Meeting was held on 6-7 April 2000, and important decisions taken are furnished below:

- Choosing of parents for breeding programme may be made on the basis of desirable characters such as genetic diversity, place of origin, synchronized flowering, cluster bearing etc.
- A project on screening of germplasm for using as root stocks for drought tolerance may be proposed.

- Kolhapur district of Maharashtra may be re-surveyed for collection of germplasm.
- All the released varieties should be evaluated for adherence of testa to the kernels, organoleptic characters, starch, quality of oil and protein content.
- Micropropagation studies may continue under DBT project and regeneration of cashew through somatic embryogenesis may continue as institute project.
- Studies on isozyme analysis for finger printing of cashew accessions may be initiated.
- In planting system and spacing trial, the biomass removed through pruning may be composted together with weed biomass in the experimental plot itself.
- Reverse terracing should be done in such a way that flow of water is checked to the maximum extent in all the plots including high density plot.
- In yield maximisation plot, trenches between two rows of cashew may be opened in irrigated area also.
- In canopy management studies pruning may be taken up soon after completion of yield (May - June).
- Digging of catch pits and terracing may be done in the first year itself and soil and moisture may be conserved in the same plot.
- Evaluation and identification of plant volatiles against cashew stem and root borers need to be done regularly at PDBC.
- Screening of pesticides against tea mosquito bug may be continued and ecological fauna in sprayed and unsprayed plots may be documented.
- The recommended dose and above the recommended dose of pesticides may be applied against cashew pests and residues may be analysed at regular intervals.
- Research on post harvest technology of cashew apple may be intensified.
- Demonstration plots may be raised with best technology (high density system of planting) generated at the research centre.
- Collaboration with Non-Governmental agencies may be made for strengthening extension activities.



10.3.4 Institute Joint Council (IJC)

Official Side

Dr.EVV.Bhaskara Rao	Chairman
Dr.MG.Bhat	Member
Sri.K.Sanjeeva	Member
Sri.A.K.Shabaraya	Member
Sri.K.Muralikrishna	Member
Dr.TN.Raviprasad	Secretary

Staff Side

Sri.KM.Jayarama Naik	Member
Sri.K.Umanath	Member (CJSC)
Sri.N.Narayana Naik	Member
Sri.K.Annu	Member
Sri.OG.Varghese	Secretary

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

10.3.5 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 अन्नू के.	सदस्य
श्री सुंदरा	सदस्य
श्री उमानाथ शेटी	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 कार्यान्वयन संबंधी विषय पर चर्चा की गयी और लिए गए निर्णयों पर अमल भी की गयी। केन्द्र के स्टोर प्रभाग में पूर्णतः हिन्दी में काम करने की कोशिश के बारे में भी निर्णय लिया गया है।

केन्द्र में दिनांक 14.09.2000 से 28.09.2000 तक आयोजित हिन्दी पखवाडा में अनेक स्पर्धाओं का आयोजन किया गया। केन्द्र में 26-27 मार्च 2001 को दो दिन की हिन्दी कार्यशाला आयोजन किया गया। कार्यशाला में डॉ. सी.एम. तिवारी, सहायक निदेशक भाषा प्रशिक्षण, डॉ. जे.पी. नौटियाल, वरिष्ठ प्रबंधक, कार्पोरेशन बैंक प्रधान कार्यालय, मंगलूर और श्री प्रकाश पै, वरिष्ठ हिन्दी अधिकारी, नव मंगलूर पत्तन न्यास, मंगलूर इन्होंने कर्मचारियों को मार्गदर्शन किये। नजदीक के अन्य कार्यालयों के कर्मचारी भी कार्यशाला का प्रयोजन लिये।

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

10.4 Participation in Symposia/Conferences/Seminars/Meetings

EVV Bhaskara Rao	Standing Committee meeting of PLACROSYM-XIV, CPCRI, RS, Kayangulam, Kerala	26 May 2000
EVV Bhaskara Rao KRM Swamy	State Level Seminar on Cashew, Hotel Prachi, Bhubaneswar	30-31 May 2000
EVV. Bhaskara Rao MG. Nayak	National seminar on High-tech Horticulture at Bangalore	26-28 June 2000
EVV. Bhaskara Rao KRM. Swamy MG. Bhat N. Yadukumar	Group meeting of Centrally Sponsored Integrated Development programmes of cashew and cocoa, NRCC, Puttur.	15 July 2000
KRM. Swamy	Meeting of Directors of ICAR Institutes / Horticulture Division, NBPGR, New Delhi.	12-14 October 2000
MG. Nayak	Meeting for finalising package of practices for cashew and rubber at KAU, Thrissur	2 November 2000
KRM. Swamy	Standing Committee Meeting of PLACROSYM-XIV, Coconut Development Board, Cochin	6 November 2000
KRM. Swamy	Executive Committee Meeting of ISPC, Coconut Development Board, Cochin	8 November 2000
MG. Nayak	Rural programme advisory committee meeting of AIR, Mangalore at ARS, Mangalore.	9 November 2000
KRM. Swamy	Meeting of the task force of quality seeds and planting material of Horticultural crops, National Horticulture Board, Gurgaon	1 December 2000
EVV. Bhaskara Rao	Workshop on "Raw Cashewnut Crop Forecasting Techniques", Mangalore Cashew Manufacturers' Association, Mangalore, Karnataka.	12 December 2000
KRM Swamy MG Bhat MG Nayak TN Raviprasad	International Conference on Plantatoin Crops - PLACROSYM-XIV, Hotel Green Park, Begumpet, Hyderabad.	12-15 December 2000



KRM Swamy MG Bhat MG Nayak TN Raviprasad	XXIX General Body Meeting of ISPC, Hotel Green Park, Begumpet, Hyderabad.	14 December 2000
MG Nayak	Indian Science Congress, 88 th Session at IARI, New Delhi.	3-7 January 2001
KV Nagaraja	Brain Storming Session on Intellectual Property Rights with particular reference to Plantation Crops at CPCRI, Kasaragod.	9 January 2001
EVV Bhaskara Rao	Project Screening Committee on Horticulture, ICAR, Krishi Bhavan, New Delhi.	19-20 March 2001

10.5 Farmers Day/Krishimela/Exhibition/Campaigns

N Yadukumar M G Nayak T N Raviprasad P S Bhat	Soil and water conservation and plant protection campaign - Gerukatte, Belthangady taluk, Dakshina Kannada district, Karnataka.	17 October 2000
	Soil and water conservation and plant protection campaign - Kavu, Puttur taluk, Karnataka	24 October 2000
	Soil and water conservation and plant protection campaign - Kollam district, Kerala	
	Soil and water conservation and plant protection campaign Keyyur (Madavu), Puttur taluk, Karnataka.	5 December 2000
KRM Swamy N Yadukumar PS Bhat R Venkattakumar	Cashew field day, ARS, Ullal, Mangalore, Karnataka.	31 January 2001
KRM Swamy N Yadukumar PS Bhat R Venkattakumar	Conference on Uttara Kannada (UK) district cashew cultivation industry organised by UK district cashew manufacturers' forum.	9 March 2001

10.6 Radio Talks/Interviews

MG Nayak	Training and pruning in cashew.	16 May 2001
MG Nayak	Pre and post harvest handling of bananas for export.	12 December 2000
TN Raviprasad	Pest management in cashew.	11 March 2001

10.7 Delegation/Training

10.7.1 Abroad : Nil

10.7.2 In India

R. Arulmony	Short course on Managing Digital Libraries in Agriculture at KAU, Trissur.	1st to 10th April 2000.
S. Bhuvanewari	69th Foundation course on Agriculture Research Service (FOCARS) at NAARM, Hyderabad.	06 January - 04 May 2000
PD Sreekanth	70th FOCARS at NAARM, Hyderabad	02 June - 29 September 2000
R Venkattakumar	71st FOCARS at NAARM, Hyderabad	25 August - 22 December 2000

10.8 Awards Won

Dr. R. Venkattakumar won Smt. Krubabai William's award (Best Student in Extension) for the year 2000 along with gold medal from Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu 641 003.

10.9 Distinguished Visitors

9-4-2000	Dr. S.P. Ghosh DDG (Hort.), Krishi Bhavan, New Delhi
9-6-2000	Dr. Kirti Singh (Ex. ASRB Chairman) Secretary, National Academy of Agricultural Sciences IARI, New Delhi 110 012
18-8-2000	Dr. D.P. Ray Professor of Horticulture Dept. of Horticulture OUAT, Bhubaneswar 751 003
21-11-2000	Dr. K.V. Ahamed Bavappa FAO Consultant & RAC Chairman Kumaranellur-679 552, Kerala
	Dr. R.T. Gunjate Reliance Petroleum Limited, RAC Member Jamnagar District-361 140, Gujarat
	Shri. Shashikant Chaudhury, RAC Member Ratanpur, Darbhanga District-847 307, Bihar
	Dr. B.R. Hegde Director of Research (Retired), RAC Member UAS, Bangalore-560 065
	Dr. A. Regupathy Professor of Entomology & RAC Member, TNAU, Coimbatore-641 003
28-2-2001	Dr. Vernon Atherstone Horticulture Consultant IDC, South Africa
	Mr. Sunil Kooverjee Specialist, Agri Projects IDC, South Africa

11. PERSONNEL

Managerial

Director EVV Bhaskara Rao

Scientific

Discipline	Scientist	Scientist (Sr.Scale)	Sr.Scientist	Pr.Scientist	Total
Agricultural Engg. (ASPE)	S. Bhuvanewari		—	—	1
Agricultural Entomology	—	P. Shivarama Bhat T.N. Raviprasad	D. Sundararaju	—	3
Agril.Extension	—	R. Venkattakumar (from 14.6.2000)	—	—	1
Biochemistry (Pl.Sci.)	—	—	—	KV Nagaraja**	1
Biotechnology	—	—	—	Thimmappaiah** (Gen.& Cyto.)	1
Computer Appl.	PD.Sreekanth	—	—	—	1
Genetics & Cytogenetics	Shirly R Anil	—	—	—	1
Horticulture	Vacant	—	MG Nayak	KRM Swamy MG Bhat** (Pl.Br.)	4
Plant Physiology	D.Balasubramanian*	—	—	—	1
Soil Science		—	N Yadukumar (Agron.)	—	1
Soil & Water cons. Engg.	Vacant	—	—	—	1
Total					16

* Temporarily adjusted against this post.

** Promoted to Principal Scientist under career advancement scheme with effect from 27.07.1998.



Technical

Sri.K.Muralikrishna,	Farm Superintendent (T6)
Sri.P.Adbulla,	Farm Superintendent (T6)
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) (w.e.f. 1.1.2000)
Sri.N.Manikandan	Technical Officer (T-5) (w.e.f. 1.7.2000)

Sri R.Muthuraju, K.Seetharama (T-4); Lakshmipathi (T-4) (w.e.f. 24.8.2000), R.Lakshmisha (T-4) (w.e.f. 15.9.2000), KV.Ramesh Babu (T-4) (w.e.f. 21.9.2000), M.Sardar Baig, R.Shekara Naik (T-II-3); KR.Padmanabhan Nair, A.Poovappa Gowda (T-I-3); Ravishankar Prasad (T-2) (w.e.f. 28.7.2000), K.Babu Poojary (T-2) (w.e.f. 20.7.2000); Bejmi Veigus, KK.Madhavan, K.Umanath (T-1)

Administrative

Sri.A.Keshava Shabaraya,	Asst.Fin.& Acnts.Officer
Sri.K.Sanjeeva,	Asst. Admn. Officer
Sri. K.M. Jayarama Naik,	Asst.Admn. Officer

Sri.V.Ahamed Bava (Sr.Stenographer); Smt.B.Jayashree, Sri.O.G.Varghese (Stenographers); Sri.MS.Satyanarayana (Assistant), Sri.K.M.Lingaraju (Sr.Clerk); Mrs.M.Ratna Ranjini, Miss.Winne Lobo, Sri.Rosario Mascarenhas (Sr.Clerk); Mrs.Leela, Sri.Uma Shankar (Jr-Clerk); Sri.K.Balappa Gowda (Gestetner Operator)

12. INFRASTRUCTURE DEVELOPMENT

- Completion of construction of Guest House cum Trainees Hostel.
- Automation (computerization) of library / documentation.
- Laying out roads in residential area.

13. MISCELLANEOUS

13.1 Graft production

During the year 2000, a total of 68,061 softwood grafts of different cashew varieties worth Rs. 10,20,915 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.

During the year 2000, a total of 1,61,389 softwood grafts of different varieties were prepared, of which about 1,13,000 saleable grafts would be available for distribution during the planting season of the year 2001. In addition to this, about 18,000 carry over grafts of previous years are also available for distribution.

13.2 Weather data (2000-2001)

Months	Temperature (°C)		Humidity (%)		Total rain fall (mm)	Rainy days	Sunshine Hours	Evaporation	Wind velocity /Hour
	Max.	Min.	FN	AN					
Apr.2000	35.9	24.2	90	52	26.0	3	7.0	5.4	4.1
May	33.6	23.7	91	58	231.8	11	6.4	4.7	3.2
Jun.	29.2	22.8	95	80	1003.2	25	1.9	2.3	3.2
Jul.	29.1	22.5	96	77	711.8	24	2.8	2.7	4.4
Aug.	26.2	22.8	96	76	622.4	21	2.5	3.0	3.7
Sept.	31.1	23.3	95	67	238.2	18	4.1	3.3	2.8
Oct.	31.6	22.8	95	65	172.8	9	4.9	2.7	2.5
Nov.	34.1	21.4	90	46	65.2	4	7.8	3.4	2.3
Dec.	33.2	17.2	91	35	22.4	3	7.7	3.5	2.2
Jan.2001	34.4	19.0	92	39	0.0	0	7.9	3.4	2.2
Feb.	35.2	20.9	93	43	0.0	0	7.7	4.3	2.8
Mar.	36.0	21.3	90	41	0.0	0	8.4	5.9	3.3

सारांश

इस अनुसंधान केन्द्र में चार तदर्थ भा.क.अनु.प. परियोजनाओं, प्रत्येक डी.बी.टी. और एन.ए.टी.पी. परियोजनाओं मिलाकर 19 अनुसंधान परियोजनाओं चालू है। इनमें प्रत्येक छः परियोजनाओं फसल सुधार तथा फसल प्रबंधन में, प्रत्येक तीन फसल संरक्षण तथा कटाई उपरान्त प्रौद्योगिकी और एक प्रौद्योगिकी हस्तांतरण में शामिल थे।

रोपण काल में तामिलनाडु(2) तथा केरल (12) से प्राप्त कृन्तक एक्सेशनस को राष्ट्रीय काजू जीन बैंक में रोपित करने से अब तक 433 एक्सेशनस उपलब्ध है। आई.पी.जी.आर.आई. के सिफारिशों के अनुसार 42 एक्सेशनस (1990 रोपित) का मूल्यांकन तथा चरित्रवर्णन किया गया है। 102 एक्सेशनस का “काजू जननद्रव्य का न्यूनतम वर्णन कैटलॉग-III” प्रकाशित किया गया। कुल मिलाकर 255 एक्सेशनस का चरित्रवर्णन तथा कैटलॉग बनाया गया है। कडलूर-1 (S-283/3) का एक वियोजक, बीना, गुच्छ फलधारण, छोटा गुटली तथा कालपूर्व पुष्पण दिखाया। काजू संकरीकरण का नेटवर्क कार्यक्रम में 65 एक्सेशनस अनुवंशिक विविधता तथा आर.ए.पी.डी. के आधार पर चुने गये। क्रॉसिंग प्रोग्राम में 191 संयोगो निर्धारित किये गये। काजू सेब उत्पन्नो का तैयारी के लिए काजू एक्सेशनस मूल्यांकित किये गये। इसमें टैनिन, फ्लेवनाइड्स, शर्कर, आस्कार्बिक आम्ल तथा संचयी हेडानिक स्कोर शामिल थे।

वि.आर.ए-2 (कम फीनॉल) तथा हेच-4-7 (साधारण फीनॉल) का पत्ता खण्डो से कैलस उत्पन्न पाया गया। 2, 4-डि सहित कैनेटिन मीडियाँ पर हेच-4-7 तथा वि-आर.आई-2 पत्ता कल्चरों में जड़ विरचन मिला गया। क्षेत्र रोपित परखनली वर्धित पौधे साधारण पौधे से उत्कृष्ट पाया गया और साधारण रूप से पुष्पण पाया गया।

अंतराल तथा रोपण पद्धति परियोजनाओं में 384, 312 तथा 236 पेड़ / हेक्टर प्लाटों से 970, 893 तथा 625 कि.ग्रां/हेक्टर का उपज पाया गया। बिना छँटाई प्लाटों से छँटित प्लाट का उपज उत्कृष्ट रहा। चापाकार बाँध बनाकर मिट्टी तथा पानी संरक्षण करने से उपज द्विगुण हुआ। दो काजू पंक्तियों के बीच नारियल छिलका गाड़ने से उपज में बड़ोत्री मिला।

रासायनिक हस्तक्षेप से कुब्जता उत्पन्न करने के लिए किये गये प्रयोगों में, मिट्टी में पैक्लोब्युट्रसाल मिलाने से पौधों का ऊँचाई, छतरी विस्तार, पुष्पित तथा अपुष्पित शाखाओं का लंबाई में कमी पाया गया लेकिन पुष्पित शाखाओं का संख्या और प्रत्येक पौधे का गुटली उपज में बड़ोत्री मिली।

काजू काण्ड और जड़ छेदक तथा चाय मच्छर का समग्र कीट नियंत्रण प्रयोगों जारी रहा। काजू छिलके और फ्रांस से मिले सार तथा बाष्पशील वस्तुओं का स्वरूप GC-MS द्वारा पहचाना गया। पौधस्वच्छता जारी रखने से काजू काण्ड और जड़ छेदक पीडित प्लाटों में कीटसंख्या में कमी आयी।

काजू टुकड़ों से काजू दूध और काजू स्प्रेड तैयार कर सका। काजू स्प्रेड को $<0^{\circ}\text{C}$ में छः महीने तक संग्रह कर सका। काजू गरी तेल अन्य तेलो जैसे मूँगफली तेल, सूर्यमुखी तेल और बदाम तेल से भी बेहतर संचयी स्थिरता दिखायी। निर्वसीकृत काजू गरी टुकड़ों से मीठा तथा स्वादित काजू स्प्रेड बनाया गया। बबूल गोंद, गौर सेम गोंद तथा माँडी काजू टुकड़ों पर लेपन प्रमाण पर प्रभाव नहीं दिखाया। लोगों को स्वीकृत मीठा, स्वादित और रंगित काजू गरी टुकड़ों को बनाया गया।

तकनीकी हस्तांतरण के अन्तर्गत इस साल में तीन आदर्श काजू बगानों उच्च धनत्व रोपण पद्धति में स्थापित होने से प्रात्यशिक्षिकावों का कुल संख्या 81 हुआ है। के.जे.पी.फाँडेशन, तिरुवनन्तपुरम; एस.के.डी.आर.डी.पी, धर्मस्थला और श्री दुर्गा चारिटेबल ट्रस्ट, केय्यूर के सहयोग में आयोजित मिट्टी और जल संरक्षण तथा कीट नियंत्रण अभियानों में 500 तक कृषिकों भाग लिए। काजू उत्पादन तकनीकी तथा उद्भिज्ज प्रवर्धन के अलावा, कृषक महिलावों के लिए कृ.वि.कें., सी.पी.सी.आर.ऐ., कासरगोडू, सी.एफ.टी.आर.ऐ., स्थानिक केंद्र, मंगलूर तथा कृषि विभाग, केरळा के सहयोग में काजू सेब उपयोग के बार में एक प्रशिक्षण कार्यक्रम आयोजित था।