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



Correct Citation

**National Research Centre for Cashew
Annual Report 2003-'04, Puttur, Karnataka**

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भूमिका

PREFACE

I am pleased to present the Annul Report 2003-04 of National Research Centre for Cashew, Puttur in which activities of the centre for the period from April 2003 to March 2004 are covered. During the period, the centre has implemented diverse projects under the areas of Crop Improvement, Crop Management Crop Protection, Post-Harvest Technology, Transfer of Technology and Computer Application.

The centre has continued its efforts to collect germplasm materials and 13 diverse types have been identified for collection from North Eastern States, which are non-traditional areas for cashew cultivation. Facilities for DNA finger printing/molecular characterization have been developed at this centre and it is contemplated to do molecular characterization of all the germplasm accession maintained at this centre. The technique of limb pruning was helpful in obtaining bushy shape with more fruiting points even in the trees with sparse and extensive branching habit. Glyricidia grown as intercrop during the initial years of cashew orchard contributed substantially for enriching the nutrient status of the soil. For predicting outbreak of Tea Mosquito Bug (TMB) in cashew plantation, monitoring minimum temperature alone may be an useful tool. The residues of insecticides used for the management of Cashew Stem and Root Borer (CSRB) and TMB were not detected in farm gate samples. Wide variation has been observed in the Mineral composition of defatted cashew kernel flour of released varieties. The centre continued its collaboration with DCCD, Kochi, SKDRDP, Dharmasthala and Development Departments for technology transfer activities.

This Annual Report embodies the results of the research projects carried out by my colleagues through implementation of the technical programmes in their projects. I welcome the suggestions of the readers of this report for improving output of our research efforts.

I am grateful to the Editorial Committee members for compilation of achievements of the centre during the year.

Place : NRCC, Puttur
Date : 18 August 2004

(M. Gopalakrishna Bhat)
Acting Director

.. सारांश

EXECUTIVE SUMMARY

During the year, a total of 21 projects including three ad-hoc projects of ICAR and NATP were in operation to achieve the mandate of the institute. Germplasm surveys were undertaken in North Eastern States viz., Assam, Meghalaya and Tripura and 13 diverse types have been identified for collection. Accessions collected from Kerala viz., Akshaya, Amrutha, Anagha, Dharashree and Sulabha have been planted in NCGB bringing the total number of germplasm accessions conserved so far in gene bank to 478. Nine accessions in NCGB having unique attributes of scientific / commercial value were accepted for registration by the Plant Germplasm Registration Committee at NBPGR, New Delhi. Three hybrids namely H-1250, H-1205 and H-1273 were promising with cumulative yield of 22.57, 19.71 and 18.75 kg/tree respectively for nine harvests, under varietal improvement trials. Micropropagation of three root stocks namely H-4-7, VRI-1 and Goa 11/6 were undertaken and rooted shoots were hardened and established in green house. DNA from 37 released varieties/elite material of cashew have been extracted and estimated.

After eight harvests, cumulative yield of 4717 kg/ha was recorded with tree density of 500 trees/ha in the planting systems and spacing trial. The same treatment was better even under unpruned condition with a cumulative yield of 4294kg/ha. Limb pruned older trees with overlapping canopy, produced compact and bushy structures even in sparse and extensive branching cashew varieties. In sloppy lands, terracing with crescent bunding was the best soil and water conservation measure. Under organic farming trials, it was found that dry matter production of green biomass obtained from glyricidia was 5.75 t/ha and contributed maximum green biomass which is equal to 186 kg N, 40.8 kg P₂O₅ and 67.8 kg K₂O/ha.

Chlorpyrifos and monocrotophos broke down after seven days of treatment under field conditions and were non-toxic to nascent grubs of CSRB. In a larger plot, λ -cyhalothrin (0.003%) was effective and it can be recommended for the management of TMB as an alternate insecticide, which is cheaper, compared to carbaryl. Monitoring minimum temperature alone may be an useful tool in predicting the possible outbreak of TMB in cashew plantation. The residues of insecticides used for the management of CSRB and

TMB viz., endosulfan, carbaryl, chlorpyrifos and lindane were not detected in the kernels obtained from the farm gate samples.

Large quantity of cashew apple pomace was prepared for feeding trials with Japanese quails in collaboration with ICAR Research Complex for Goa. Wide variation has been observed in the mineral composition of defatted cashew kernel flour of 28 released varieties

A total of 17 plots were selected and demonstrations were laid out mainly on high density system of planting and intercropping bringing the total number of demonstration plots laid out so far by this Centre to 106 in the farmers' fields.

Four thematic campaigns were organized on soil and water conservation (SWC) measures in cashew, high density planting in cashew, pruning in cashew and plant protection in cashew. Training programmes on "Vegetative Propagation of Cashew", "Cashew Production Technology" and "Pruning and Top working in Cashew" were organized for the benefit of farmers and officials of development departments. Annual "Cashew Day" was organized with a theme of "Cashew Based Cropping Systems". The perceived opinion of demonstration farmers towards recommended Soil and Water Conservation (SWC) and plant protection measures in assessed. User friendly and menu driven cashew database has been developed in Visual Basic. During 2003 planting season, around 96,000 cashew grafts of different varieties were distributed to farmers and development departments. The results of all the ongoing research projects are presented in this "Annual Report".

INTRODUCTION

Research on cashew was first initiated in the early 1950s. Indian Council of Agricultural Research (ICAR), sanctioned ad-hoc schemes for Research Centres located at Kottarakkara (Kerala), Ullal (Karnataka), Bapatla (Andhra Pradesh), Daregaon (Assam) and Vengurla (Maharashtra). In 1971, ICAR also sanctioned All India Coordinated Spices and Cashew Improvement Project (AICS and CIP) with its Head Quarters located at CPCRI, Kasaragod. The CPCRI Regional Station, Vittal (Karnataka) was given the mandate to work on cashew while four University Centres (Baptala, Vridhachalam, Anakkayam and Vengurla) were assigned the research component on cashew under AICS and CIP. During the V and VI plan three more centres (Bhubaneswar, Jhargram and Chintamani) came under the fold of AICS and CIP and with shifting of work of Anakkayam centre to Madakkathara. The recommendations made by the Quinquennial Review Team (QRT) constituted by ICAR in 1982, working group on Agricultural Research and Education constituted by the Planning Commission for VII Plan Proposals and the Task Force on Horticulture constituted by ICAR has resulted in the establishment of National Research Centre for Cashew at Puttur on 18th June 1986. Subsequent to the bifurcation of AICS and CIP, the headquarters of All India Coordinated Research Project on Cashew was shifted to NRC for Cashew, Puttur. At present, this Coordinated Research Project is operating in eight centres and a sub centre distributed in major cashew growing areas of the country.

MANDATE

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

- To generate quality planting material.
- To collaborate with national and international agencies for achieving the mandate.

ORGANIZATIONAL SET UP AND INFRASTRUCTURE

- National Research Centre for Cashew is located at Puttur, Dakshina Kannada, Karnataka. The main campus is situated 5 KM away from Puttur town (at Kemminje: 12.45° N latitude, 75.4° E longitude and 90m above MSL).
- The main campus has an area of 68 ha with field experiments and Laboratory-cum-Administrative Block. Experimental Station at Shantigodu, which also forms part of the Research Centre is 13 Km away from the main campus and has an area of 80 ha.
- The centre has got well-established library in the field of cashew research. The library is serving as an information centre on all aspects of cashew research and development in the country. The CD database viz., CABHORT, CABPEST, AGRICOLA and AGRIS, SOIL CD, CROP CD, PLANTGENE CD are also available in the library. The library also has library automation software and bar- coding facility.
- The centre has got local area network of computers with Internet connections. The centre has got its own website which is updated at montly intervals.
- The headquarters of AICRP on Cashew is located at NRC Cashew, Puttur. It has eight Coordinating Centres and a Sub-Centre located in Karnataka, Kerala and Maharashtra in West Caost, Andhra Pradesh, Orissa, Tamil Nadu and West Bengal in the East Coast and in Chattisgarh.

Significant achievements of the centre:

- It has the largest germplasm collection of cashew in the country (National Cashew Field Gene Bank) with 478 acessions. A total of 433 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 standardized.
- Micrografting technique for *in vitro* multiplication of cashew has been standardized and cashew plants raised by micro grafting have been potted.
- It has also demonstrated the advantage of growing intercrops like pineapple and turmeric profitably in cashew gardens.
- Glyricidia grown as intercrop during initial years contributed 5.75 t/ha of dry matter, equal to 186 kg N, 40.8 kg P₂O₅ and 67.8 kg K₂O/ha.
- Individual tree terracing with crescent bunding is the best soil and water conservation measure in sloppy lands.
- High density planting (625plants density/ha) was shown to be better than normal spacing (8m x 8m) resulting in a yield increase by 2.5 times over control in the initial ten years.
- Irrigating cashew at 60-80 litres of water/tree once in four days through drip after initiation of flowering till fruit set and development in combination with the application of 750: 187.5: 187.5 g of NPK/tree led to significant higher yields.
- Softwood grafting method has been standardized and its feasibility for the commercial multiplication has been demonstrated and this technique is being commercially utilized for large scale production of planting material in cashew in the country.

- The rearing technique for cashew stem and root borer (CSRB) on host bark has been standardized. Volatiles and extracts in hexane from both healthy bark and frass on testing by EAG elicit response from adult female beetles of CSRB.
- Laboratory rearing technique for tea mosquito bug (TMB) has been standardized. Among the new insecticides evaluated against the pest, λ -cyhalothrin was very effective in reducing the damage under field condition.
- Sweetened and flavoured spread could be prepared from cashew kernel baby bits. Cashew kernel baby bits could be coated with different combination of flavour and colours. Cardamom flavoured and apple green / saffron coloured and sweetened cashew kernel baby bits are most preferred. Sweetened and flavoured cashew kernel baby bits could be stored without quality deterioration for 12 months at ambient temperature.
- Defatted cashew kernel flour of 28 released varieties has been analysed for mineral composition and wide variation was observed.
- The centre has established very good linkage with farmers and officials of State Departments and Development Agencies.

Budget (2003-'04)

(Rs. In lakhs)

Plan	Non-Plan	External	Total
86.38	146.45	12.33	245.16

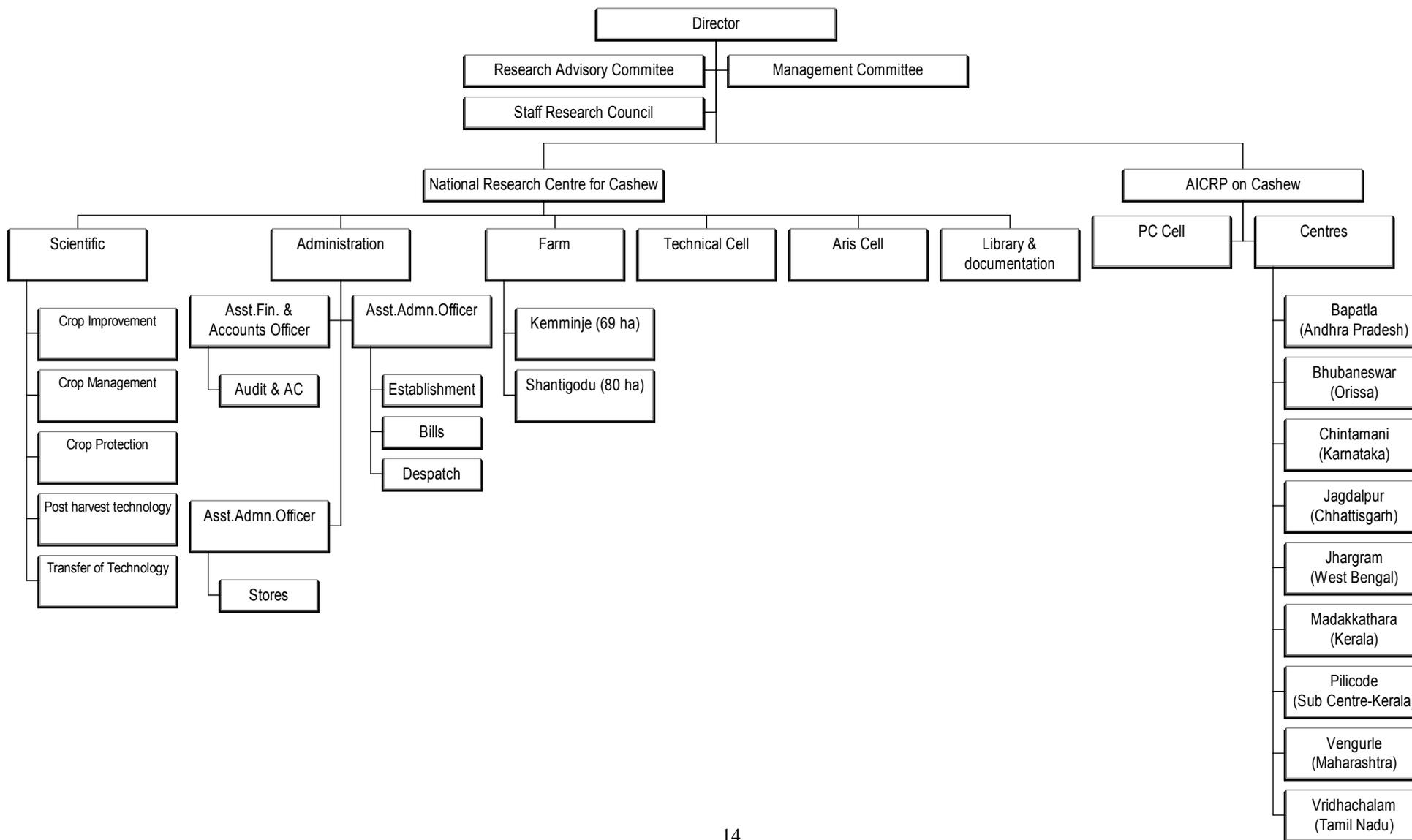
Staff Position as on 31.3.2004

Category	NON PLAN			PLAN			TOTAL		
	Sanct- ioned	Filled	Vacant	Sanct- ioned	Filled	Vacant	No. of Posts	No. filled No.	Vacant
Director (RMP)	1	-	1	-	-	-	1	-	1
Scientific	16	13	3	-	-	-	16	13	3
Technical	20	19	1	4	-	4	24	19	5
Administrative	14	12	2	1	-	1	15	12	3
Supporting	42	41	1	-	-	-	42	41	1
Canteen	1	1	-	-	-	-	1	1	-
Total	94	86	8	5	-	5	99	86	13

Total Manpower

	Sanctioned	Filled	Vacant
Non Plan	94	86	8
Plan	5	-	5
Total	99	86	13

ORGANISATIONAL SETUP OF NRC-CASHEW





RESEARCH ACHIEVEMENTS

1. CROP IMPROVEMENT

Genetic resources of cashew

1.1.1 Germplasm collection

In Assam, Golpara, Kamrup and Dhuburi districts were surveyed and three trees were identified in Dhuburi districts for collection. In Meghalaya seven germplasm with elite characters were identified in West Garo hill district. Similarly three elite trees were identified in Tripura state in the germplasm collection of Nagichera farm of state department of horticulture.

Grafts of identified material have been prepared for planting in NCGB during next year planting season. Another two high yielding bold nut types identified at Kavuvu of Puttur taluk and grafts have been prepared for conserving them in NCGB. Also from the evaluation of seedling material collected from Mozambique available in NCGB a semivigorous, compact having medium nuts was multiplied clonally for planting in NCGB.

1.1.2 Germplasm conservation

Grafts of five cashew germplasm of varieties released for cultivation by Kerala Agricultural University viz., Akshaya, Amrutha, Anagha, Dharashree and Sulabha have been planted in NCGB at Shantigodu campus for evaluation and conservation. So far a total of 478 accessions have been conserved in NCGB.

1.1.3 Characterization of germplasm

The germplasm accessions planted during 1993 (NRC 286 to 300) were characterized as per IPGRI cashew descriptors during the fruiting season of 2002-03 after the completion of six annual harvests taking the total number of accessions characterized so far to 300. Of the 15 accessions, NRC 298 accession did not yield during the season due to severe pest damage and hence the nut characters could not be recorded.

Among the 14 accessions characterized, majority had upright and open canopy (11), obovate leaf shape (11), extensive branching (11), yellow red young leaves (9), early flowering (13), yellow red apple colour (3), conical obovate apple shape (10), intermediate to high nut weight (14), high cashew apple weight (11), loose nut to apple attachment, medium shell thickness (14), medium flowering duration (7), medium apple to nut ratio (11), intermediate shelling percentage (9), loose attachment of peel to kernel (14) and low cumulative yield (10) (Table 1.1).

1.1.4 Germplasm registration

Germplasm of agri-horticultural, commercial and other economic crops which is unique having potential (verified / verifiable) attributes of scientific / commercial value are registered by the Plant Germplasm Registration Committee at NBPGR. Out of 19 accessions only nine accessions with distinct features (Table 1.2) are accepted for registration.

1.2 Varietal improvement of cashew

1.2.1 Evaluation of hybrids/selfs

Highest cumulative yield of 16.04 kg/tree for eight harvests was recorded in S-15/14 Self (1/3 Ceylon self) as compared to 12.94 kg/tree in VRI-2 (control) in a replicated trial. Hybrids H 24/4 (BLA 139-1 x A 18/4) and H 6/18 (BLA 139-1 x 13/5 Kodur) performed well for cumulative yield (11.65 kg/tree and 10.27 kg/tree respectively) in another replicated trial as against cumulative yield of 5.03 kg/tree in case of control (VRI-2). The highest annual yield (5.52 kg/tree) in 5th harvest was recorded in H 6/18 as against annual yield of 2.00 kg/tree in case of VRI-2.

Large number of hybrids belonging to over 270 cross combinations are under evaluation for various important economic characters. Three hybrids, namely, H 1250, H 1205 and H 1273 of cross VRI-2 x VTH 40/1 were found promising under medium nut size category with cumulative yield of 22.57 kg/tree, 19.71 kg/tree and 18.75 kg/tree, respectively for nine harvests. Hybrid H 1250 recorded highest

annual yield of 6.80 kg/tree during ninth harvest. Another hybrid H-2453 (BLA-39-1 x VTH 711/4) gave annual yield of 8.50 kg/tree in 5th harvest. Under the ad-hoc scheme on “Network programme on hybridization in cashew” a total of 4457 mature hybrid nuts were obtained from 532 cross-combinations at six centers including NRCC, Puttur. Hybrid seedlings obtained from these hybrid nuts have been field planted during the 2003 planting season.

A compact and dwarf cashew genotype, KGN-1 obtained from Cashew Research Station, Madakkathara Centre (Thrissur, Kerala) of AICRP on Cashew planted at 4m x 4m spacing is being evaluated for plant characters in comparison to NRCC Sel-2 (control). Grafts of KGN-1 and NRCC Sel-2 were planted in the year 2002 and their performance for plant characters are studied. KGN-1 has 26 plants and NRCC Sel-2 9 plants. KGN-1 had relatively lesser plant height (1.87 metres) as compared to NRCC Sel-2 (2.21 metres). Stem girth and mean canopy spread were also lesser in KGN-1 (16.92 cm and 2.16 meters, respectively) as compared to NRCC Sel-2 (20.66 cm and 2.32 metres, respectively).

1.2.2 Comparison of two types of pollination techniques

Two methods of pollination techniques, namely, pollination of flowers using paper roll and paper bag were compared. The initial setting and mature nuts obtained at the harvest time were determined. Twelve cross-combinations were attempted in each method. In each method 269 pollinations were made. In paper roll method 48 fruits had set while in the paper bag method 35 fruits had set with 17.84% and 13.00% setting respectively. In the paper roll method 27 mature hybrid nuts could be obtained while, in the paper bag method 12 mature hybrid nuts could be obtained. Thus, the paper roll method was found better than the paper bag method.

1.3 Molecular characterization

1.3.1 Finger printing of cashew using RAPD markers

DNA could be extracted from fresh young leaves of all 37 released and elite varieties of cashew following both the modified miniextraction protocol of Mneney et al. (1997) and also by large scale extraction protocol using liquid nitrogen (LN) and 3% CTAB buffer. The quality of the DNA checked through 0.8% agarose gel electrophoresis was good. The quantity of DNA extracted following mini extraction protocol ranged from 19 µg – 182 µg/100 mg of the tissue, and the quantity of DNA content by large scale extraction using LN procedure ranged from 0.63 µg – 2.17mg/g of the fresh tissue.

The DNA extracted when subjected to PCR reaction was found to be amenable to amplification and distinct RAPD bands were obtained. The master mix contained dNTPs (200 µM each), primer (25 p mol), Tag polymerase (3 units/µl), Buffer (10x) (2.5 µl) and MgCl₂ (25 mM) (1 ml) along with the template DNA in a 25 µl reaction mixture. The amplification condition was as follows: Initial start at 95°C for 2 min, followed by 40 cycles and each cycle consisting of denaturation at 94°C for 1 min, primer extension at 72°C for 2 min and a final extension at 72°C for 6 min. RAPD protocol was standardized using varying concentrations of dNTP (100 – 200 µM each) and quantity of DNA (25, 50, 75, 100 ng). The DNA quantity of 25, 50 and 75 ng gave good amplification and 200 µM each of the four dNTPs was ideal for getting clear RAPD bands on 1.2% agarose gel. Most of the bands obtained were in the range in 400-500 bp, when primers OPB-17 and OPB-20 were used.

1.3.2 Finger printing of cashew by isozymes

Isozymes were extracted from fresh young leaves. Esterase, glucose phosphate isomerase (GPI) phospho glucomutase (PGM), superoxide dismutase (SOD) acid phosphatase (ACP) alone gave clear bands. Isozyme profiles generated for 4 species. (*A. occidentale*, *A. pumilum*, *A. orthonianum*, *A. microcarpum* and purple plant genotype) showed that esterase, GPI, PGM isozyme pattern were polymorphic

between the species. GPI and esterase profiles studied for 21 varieties showed that esterase pattern was polymorphic between the varieties whereas, GPI pattern was monorphic between the varieties.

1.4 Micropropagation

1.4.1 Multiplication of root stocks

Multiplication of root-stocks through micropropagation was taken up by raising *In vitro* seedlings of three root-stocks namely H-4-7, VRI-1 and Goa 11/6 and excised cotyledonary nodes and shoot-tips from these seedlings and cultured on two media namely (1) full strength Murashige and Skoog (1962)(MS) medium supplemented with 2.2 mg/l benzyl adenine (BA) and 0.2 mg/l IBA and (2) MS medium containing 0.1 mg/l each of thidiazuron (TDZ) and IBA in combination. Axillary shoot bud induction was observed in both shoot tips and cotyledonary nodes. Cotyledonary nodes were more efficient than shoot tips than axillary shoot bud proliferation and induction was more in medium containing TDZ. Cotyledonary nodes of H-4-7 showed maximum induction of buds (9.2 buds/explant) followed by Goa 11/6 (4.6 buds/explant) and VRI-1 (3.3 buds/explant). Shoot buds showed elongation on hormone free medium. Some of the shoots elongated showed spontaneous rooting and could be induced to root (75%) as well on half-MS medium containing NAA + IBA (2.5 mg/l each). Rooted shoots were hardened and established in green house.

Similarly to regenerate cashew from grafts (mature tree source) nodal cultures from one year old grafts of NRC Sel-2, Ullal-3, VRI-3 and Goa 11/6 were initiated on half-MS medium supplemented with 2 g/l activated charcoal and 4% sucrose. Contamination was high (57-97%) during August and September and low (23%) during April. Maximum percent bud break and shoot formation (49% and 24% respectively) was during April month and in the shoot explants of NRC Sel-2. Single shoots showed axillary shoot-bud proliferation (3-4/culture) on MS medium containing 0.1 mg/l each of TDZ and IBA. These induced axillary buds were unable to elongate on hormone free medium. Rooting of long shoots by dipping in 100 ppm IBA for 24 h

in dark or pulsing of shoots in 10 mM IBA for 5-10 sec and culturing on hormone free medium could not elicit any response for rooting.

1.4.2 Induction of somatic embryogenesis

Bisected ovules (nucellus tissue) excised from three week old immature nuts of Kanaka, Ullal-3 and Goa 11/6 were cultured on modified MS medium containing 6% sucrose, 400 mg/l L-glutamine, Cysteine HCl (100 mg/l) and supplemented with 0.5, 1.0 and 4 μ M 2,4-D alone and 0.5 μ M 2,4-D in combination with 10 μ M Spermine. Callus induction was observed in all. Callus cultures (1 month old) were sub cultured onto four differentiating media namely hormone free Raj bhansali medium (RBM), RBM with 2,4-D (0.05) + Kin (30 μ M), 2,4-D (0.01 μ M) + Spermine (10 μ M) and 2,4-D (0.01 μ M) + KIN (30 μ M) + Spermine (10 μ M) for the induction of somatic embryogenesis. Only callus cultures of Kanaka variety showed embryogenesis (8%) on the first two media in both light and dark. Somatic embryos were matured on hormone free RBM and half-MS containing 20 μ M ABA. Germination of somatic embryos on modified liquid MS medium containing 1 μ M GA₃ showed prominent root formation and improper development of shoot

1.4.3 Evaluation of micropropagated plants

Significant difference between micropropagated plants and grafts of VRI-2 and H-4-7 was observed for plant height, stem diameter and lateral spread in a replicated trial planted in 1999. Flowering was observed in most of the plants (90%) in replicated trial. Grafts showed higher percentage of flowering (95%) than micropropagated plants (85%). Yield differences between different treatments were not significant. However, VRI2 recorded higher yield/plant (1.1 Kg) than H4-7 (0.83 Kg).

Table 1.1: Details of accessions characterized during 2003 fruiting season

Data field	Descriptor	Descriptor Status	Number of accessions
07	Tree habit	3. Upright & Compact 5. Upright & Open 7. Spreading	3 11 -
09	Leaf shape	1. Oblong 2. Obovate (Club-Shaped) 3. Oval	- 11 3
16	Branching pattern	1. Extensive 2. Intensive	11 3
19	Colour of young leaves	1. Red 2. Yellow Red 3. Green Yellow 4. Purple	2 9 3 -
28	Season of flowering	3. Early (Nov-Dec) 5. Mid (Dec-Jan) 7. Late (Jan-Feb)	13 1 -
31	Colour of mature apple	1. Yellow 2. Red 3. Yellow Red 4. Red Purple	8 6 - -
32	Shape of cashew apple	1. Cylindrical 2. Conical-Obovate 3. Round 4. Pyriform	1 10 - -
35	Nut weight	3. Low (< 5 g) 5. Intermediate (5-7 g) 7. High (> 7 g)	- 7 7
43	Weight of cashew apple	3. Low (< 27 g) 5. Medium (27-52 g) 7. High (> 52 g)	- 3 11
50	Attachment of nut to cashew apple	3. Loose 5. Intermediate 7. Tight	6 3 5

57	Shell thickness	3. Thin (<2.5 mm) 5. Intermediate (2.5-4.0 mm) 7. Thick (>4.0 mm)	- 14 -
60	Flowering duration	3. Short (< 60 days) 5. Medium (60-90 days) 7. Long (> 90 days)	1 7 6
62	Apple to nut ratio	3. Low (<6.0) 5. Medium (6.0-12.0) 7. High (> 12.0)	2 11 1
63	Shelling percentage	3. Low (< 18.0%) 5. Intermediate (18.0-28.0%) 7. High (> 28.0)	- 9 5
64	Kernel weight	3. Low (<1.2 g) 5. Intermediate (1.2-2.5 g) 7. High (>2.5 g)	1 13 -
65	Attachment of peel to kernel	3. Loose 7. Tight	14 0
68	Cumulative yield per plant (6 annual harvests)	3. Low (<9 kg) 5. Medium (9-18 kg) 7. High (> 18 kg)	10 4 -

Table 1.2: Details of cashew germplasm registered

INGR	National Identity	Donor / other identity	Novelty / unique characters (traits) for registration
03080	IC 2965	NRC 59 (VTH 196/18)	Apple and nut size and shelling percentage
03081	IC 2965555	NRC 111 (Mardol-4)	Mid season flowering, apple and nut size
03082	IC 296557	NRC 116 (CNSL free)	High apple and nut weight and CNSL free
03083	IC 296559	NRC 120 (Nairobi)	Early season flowering, bold apple and nut size
03084	IC 296561	NRC 121 (Purple type)	Purple stem and leaves and high shelling percentage
03085	IC 296564	NRC 140 (VTH 155 L)	Semitall, early season flowering (Nov-Dec) and long flowering duration (120 days)
03086	IC 296565	NRC 142 (VTH 578/1)	Wild relative with genetic diversity
03087	IC 296567	NRC 152 (VTH 713/4)	Wild relative with genetic diversity
03088	IC 296571	NRC 201 (Pl.No.1254)	Upright and compact habit, semitall type

2. CROP MANAGEMENT

2.1 Planting systems and spacing

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 system 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 system namely 5 m x 4 m (500 plants/ha), 6.5 m x 4.0 m (384 plants/ha) and 8.0 m x 4.0 m (312 plants/ha) with pruning and no pruning as sub plot treatments.

Highest yield was achieved in treatment 5 (790 kg and 647 kg/ha under pruning and no pruning conditions) and 6 (812 kg and 557 kg/ha under pruning and no pruning conditions) where the spacing maintained is 6.5mx4m (384 trees/ha) and 8mx4m (312 trees/ha) respectively. The least yield (364 kg/ha) was recorded in treatment 8mx8m (156 trees/ha) (Table 2.1). Only in high tree density plots, the pruning of overlapping branches has resulted in significant higher yield than unpruned plot of the same treatment. Cumulative yield indicated that highest yield of 4717 and 4294 kg/ha under pruned and unpruned conditions respectively were achieved from treatment with tree density of 500 trees/ha. The next highest yield of 4446 and 4141 kg/ha under pruned and unpruned conditions respectively were recorded from treatment plot with tree density of 384 trees/ha (Table 2.2).

2.2 Canopy management studies in cashew

Four cashew varieties viz., VRI-1, Ullal-1, VTH 30/4 and NRCC Sel-1 were used for the study. Pruning treatments were imposed every year soon after the harvest of the crop since 1995 onwards and during the year 5th cycle of pruning has been imposed. In general the yield was very poor due to pest damage during the season. Though, there was significant difference among various treatments due to leader

shoot pruning the trend was not consistent. As per the suggestions of RAC and QRT the limb pruning has been done as the overlapping of canopies and declined yield was observed. The control plants were left unpruned.

The trees produced new flushes from the dormant buds on the trunk and new canopy was developed in all the pruned plants. New flushes were again pruned to reduce the apical dominance due to which intensive branching of the new flushes was observed. Control measures were taken against *Monolepta* beetles and regular monitoring of CSRB was done. The prophylactic spray against CSRB and TMB was taken up as and when required.

Growth observations were recorded. In general the plants are in vegetative nature. In variety VTH 30/4 (early variety) a few flower panicles in the regular flowering season and later again only vegetative flushes were observed. In variety VRI-1 (early flowering type) had profuse flowering and fruiting a little later than regular season while the Sel-1 (late flowering type) the flowering not seen. Variety Ullal-1 has flowered profusely though a bit delay in flowering season and good yield was recorded (Table 2.3).

The canopy structure looks to be very compact and bushy in even sparse and extensive branching types. By limb pruning and severe pruning it appears that under planting can be taken up in old plantations and these old plantations can be brought under high density for increased yield per unit area if intensive care is taken after beheading of the plants. The trees in which the limb pruning has been done during 2002 May. New canopy with profuse flowering in all the four varieties observed.

An observational trial on training the cashew grafts for the development of suitable canopy indicated that cashew grafts can be trained to central leader, modified leader, vase system or bushy type by suitably pruning once or twice a year. Pruning the cashew grafts of variety Ullal-3 to bush shape by annual pruning immediately after the harvest of the crop ensures normal flowering and fruiting during ensuing season.

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

2.3.1 Experiment 1:

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 P₂O₅ and K₂O/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

For the first layer of soil, no significant difference in soil moisture content was observed among all treatment plots (Table 2.4). For the second and third layer of soil, the SMC in the crescent bund with terrace treatment was found to be significantly more than in catch pit, staggered trench and control treatments. Maximum soil moisture availability was observed within 1 m radius of the plant at the base in the case of crescent bund with terrace treatment (13 to 20.5 %) and least in the case of control plot (11 to 13.5 %) with no soil and water conservation structure. The soil moisture contents were very high (16 to 21.3%) inside the

trenches of crescent bund and staggered trench treatments. Annual runoff was estimated as 850 mm. The peak runoff from crescent bunding and catch pit with terrace treatments was 4.6 l/s, staggered trench plot was 5.0 l/s and control plot 5.1 l/s. Annual soil loss from crescent bunding and catch pit with terrace treatments were 0.77 t/ha/year, staggered trench plot was 1.16 t/ha/year and control plot 1.54 t/ha/year.

Soil conservation measures like crescent bunding with terrace resulted in higher production of nuts (706 kg/ha). The yield under different treatments like individual terracing with catch pit and staggered trenches did not vary significantly compared to control (Table 2.5). Application of recommended doses of fertilizer with poultry manure and poultry manure alone resulted in higher yield than recommended doses of fertilizers and control. Interaction effects of both soil conservation measures and manures were not observed (Table 2.5).

It was found that the crescent bunding with terrace treatment has increased the soil moisture content significantly (141% of control), reduced the peak runoff (10% of control) and soil loss (50% of control) and resulted an increase in the cashew yield (188% of control).

2.3.2 Experiment 2:

Treatments (5)

- T1 : Modified crescent bunding with vetiver (Bio Engg)
- T2 : Staggered trenches with coconut husk burial between 2 rows of cashew
- T3 : Platform terraces
- T4 : Catch pits
- T5 : Control plot without any soil and water conservation measure

Design : RBD, Replications : 4

Contour survey was conducted and contour map was plotted to get the slope of the land. The surface modeling was done using surfer 7.0 to get a 3-D view of the hillocks

(Fig.2.1). The slope of the treatments ranges from 4 to 43%. The 4 replications were laid on 4-15% slope, 18-23% slope, 25-33% slope and 34-43% slope. All the treatments in one replication has almost same slope to avoid the error due to slope. The field capacity of the soil was determined as 22%. For the first layer of soil, the soil moisture content (SMC) in the coconut husk burial and the modified crescent bund treatments were found to be significantly higher than other treatments (Table 2.6). For the second and third layer of the soil, the SMC in the coconut husk burial, modified crescent bund and platform terrace treatments were significantly more than that of catch pit and control. Maximum soil moisture availability was observed within 1 m radius of the plant at the base in the case of coconut husk burial treatment (18.65 %) and least in the case of control plot (11.47 %) with no soil and water conservation structure. The soil moisture contents were very high (17.39 to 18.65 %) inside the trenches of the coconut husk burial and the modified crescent bund treatments. Annual runoff was estimated as 882 mm. Infiltration rate of the soil at the upstream, middle and downstream of the hill was recorded using double ring infiltrometer. The average maximum infiltration rate was 43.9 cm/h. The average constant infiltration rate was 11.0 cm/h (Fig.2.2).

2.4 Influence of fertigation on yield and quality of cashew

The Ad-hoc scheme on Influence on yield and quality of cashew had the following objectives.

2.4.1 Objectives

- i) To work out optimum quantities of fertilizers to be applied through drip system for yield maximization under normal and high density planting system.
- ii) To asses effect of fertigation and combinations of fertilizers and organic manuring under two different plant densities

- iii) To assess quality of nuts produced due to fertigation and combination of nutrient application through fertigation and organic manures.

Two separate experiments were laid out in the field as per approved plan of layout.

2.4.2 Experiment-1

The experiment was laid with VRI- variety. Highest production of nuts/tree (5.14 kg) and per hectare (1028 kg) was observed when trees were subjected to fertigation with 50 % of recommended doses of fertilizers (250 g N, 62.5 g each of P₂O₅ and K₂O/tree/year), and remaining 50 % applied in the form of castor cake which was on par with above dose of fertilizers and remaining applied in the form of neem cake and these two treatments were significantly superior to rest of the treatments.. Lowest yield was recorded in the trees treated with soil application of 50 % of 500g N, 125g each of P₂O₅ and K₂O/tree/ year (Normal recommended dose) and remaining NPK in the form of castor cake (M10). This indicated that even with lower dose of fertiliser application the fertiliser use efficiency was more if it is applied through fertigation (Table 2.7).

In general when trees were treated with normal and higher doses of fertilisers through fertigation or half of these doses applied through fertigation and remaining half applied through soil in the form of organic manure increased yield substantially compared to application of normal and higher doses to soil (Table 2.7)

Significant difference was not observed among the treatments of three different irrigation rates. The treatment M3 (50 % of Normal dose of fertilisers applied through fertigation and remaining applied to soil in the form of castor cake) resulted in significant increase in nut weight of 7.2 g over all other treatments. Least nut weight (6.3 g) was observed in the case of treatment of 50 % of 750g N, 188g each of P₂O₅ and K₂O/tree/ year (Higher doses of fertilisers) in the form of inorganic and remaining in the form of neem cake both applied to the soil (M11). Different treatments did not have any significant difference in apple weight. The treatment M6 (50 % of higher dose of fertilisers applied through fertigation and remaining applied to soil in the form of castor cake) resulted in significant increase in shelling per cent of 30.9 over all other

treatments. Least shelling per cent (28.8) was observed in the case of control treatment where neither fertilizer nor organic manures were applied (M13). Different irrigation rates (S1-20% CPE, S2-40% CPE and S3-60% CPE) did not have any significant effect on yield, nut weight and shelling percent. Soil and leaf nutrient contents were high in plots where nutrients were given through fertigation compared to those plots receiving nutrients applied directly to soil.

2.4.3 Experiment-2

The experiment was laid with Goa 11/6, a promising accession. Highest yield/tree (2.3 kg) and per hectare (1438kg) was recorded when trees were subjected to 50 % of lower dose of fertilizers (250 g N, 62.5 g each of P₂O₅ and K₂O/tree/year and remaining 50 % in the form of neem cake both applied to soil (Table 2.8). Lowest yield was recorded in the trees receiving control treatment (M13). Among the treatments of three different quantities of water no significant difference in yield was observed.

Highest nut weight (7.5 g) was recorded when trees were subjected to 50 % of lower dose of fertilizers (250 g N, 62.5 g each of P₂O₅ and K₂O/tree/year) applied through fertigation and remaining 50 % in the form of castor cake applied to soil (M3), 50 % of normal dose of fertilizers (500 g N, 125 g each of P₂O₅ and K₂O/tree/year) applied through fertigation and remaining 50 % in the form of castor cake applied to soil (M6), 50 % of normal dose of fertilizers (500 g N, 125 g each of P₂O₅ and K₂O/tree/year) and remaining 50 % in the form of neem cake both applied to soil. Different quantities of water also showed increased nut weight up to medium level of irrigation.

Treatment effect on shelling percent was absent. Different water levels did not show any difference in shelling per cent. Treatment number 1 to 6 indicated highest apple weight (76.1 to 77.9 g) which are significantly superior to rest of the treatments indicating either application of full recommended or lower doses of NPK in the form of inorganic manure through fertigation or combination of application of 50 % in the form of inorganic manure applied through fertigation and remaining applied in the form of castor or neem cake (organic manure) to soil is far better than

application of inorganic manure alone or combination of both inorganic and organic manure applied to soil (69.9 to 74.2 g) or no application (71.1 g) of manure at all .

Soil and leaf nutrient contents were high in plots where nutrients were given through fertigation compared to those plots receiving nutrients applied directly to soil. In general kernels contained higher more protein content (41.7%) in plots receiving nutrients through fertigation compared to those plots not receiving fertigation (37.9%).

Table 2.1: Annual yield in relation to tree density

Tree density (Nos./ha)	Annual yield (kg/ha) – 8 th harvet			
	Pruned	Unpruned	Mean	% of control
400 (5 x 5)	485	313	399.3	78.3
236 (6.5 x 6.5)	674	622	647.8	127.0
156 (8 x 8)	432	587	509.8	100
500 (5 x 4)	300	375	337.5	66.2
384 (6.5 x 4)	790	647	718.5	140.9
312 (8 x 4)	812	557	684.6	134.3
Mean	582	517		
CD for main plot (P=0.05)			171.3	
CD for subplot (P=0.05)			55.5	

Figures in the parantheses indicate the spacing in metres

Table 2.2: Cumulative yield in relation to tree density

Tree density (Nos./ha)	Cumulative yield (kg/ha) – 5 th to 12 th year (8 harvests)			
	Pruned	Unpruned	Mean	% of control
400 (5 x 5)	4029	3445	3737	202
236 (6.5 x 6.5)	3373	3355	3243	147
156 (8 x 8)	2010	1682	1846	100
500 (5 x 4)	4717	4294	4506	244
384 (6.5 x 4)	4446	4141	4294	233
312 (8 x 4)	3849	3649	3749	203
Mean	3737	3427	3703	

Figures in the parantheses indicate the spacing in metres

Table 2.3: Effect of limb pruning on growing behaviour of plants

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

Table 2.4: Mean soil moisture (% dry bands) availability under different treatments

Treatment	Depth (cm)			Mean
	0-30	30-60	60-90	
Individual tree terracing with catch pit	12.2	16.5	18.2	15.6
Individual tree terracing with crescent bunding	13.0	18.7	20.5	17.4
Staggered trenches between two rows of cashew	11.7	14.8	17.4	14.6
Control plot without any soil conservation technique	11.4	11.9	13.5	12.2
Mean	12.1	15.5	17.4	
CD Treatment (P=0.05)				2.62
CD Depth (P=0.05)				2.26
T x D				NS

Available soil moisture ranges from 12 % to 22 %

Table 2.5: Influence of organic and inorganic manuring coupled with soil and water conservation techniques on nut yield of 13 year old cashew orchard (kg/ha)

Treatment	Subplot treatments			Mean
	1	2	3	
Individual tree terracing with catch pit	538	553	604	566
Individual tree terracing with crescent bunding	674	734	714	706
Staggered trenches between two rows of cashew	548	620	538	568
Control plot without any soil conservation technique	376	438	502	436
Mean	534	584	588	569
CD for Main Plot				74.9
CD for Sub Plot				NS

(1 = Application of recommended doses of fertilizers only, 2 = Application of recommended doses of fertilisers + organic manure, 3 = Application of organic manure only (20 kg poultry manure)).

Table 2.6: Mean soil moisture (% dry basis) availability under different treatments

Treatment	Depth (cm)			Mean
	0-30	30-60	60-90	
Modified crescent bunding with vetiver (Bio Engg)	14.45	17.90	19.82	17.39
Staggered trenches with coconut husk burial between 2 rows of cashew	15.75	19.27	20.92	18.65
Platform terraces	12.02	15.42	17.42	14.95
Catch pits	11.90	13.45	15.5	13.62
Control plot without any soil and water conservation measure	10.07	11.32	13.02	11.47
Mean	12.84	15.47	17.34	
CD Treatment (P=0.05)				1.24
CD Depth (P=0.05)				0.96
T x D				NS

Available soil moisture ranges from 12 % to 22 %

Table 2.7: Influence of fertigation on yield kg/tree and kg/ha in VRI-1 variety under normal density planting system

Treatments	Yield kg/tree and kg/ha			
	1	2	3	Mean
M1: 500 g N, 125 g P ₂ O ₅ , 125 g K ₂ O/plant applied through fertigation	1.12 (224)	0.86 (172)	1.10 (220)	1.03 (206)
M2: 50% of above nutrients applied through fertigation and remaining 50% through soil application in the form of neem cake	5.40 (1080)	4.44 (888)	4.18 (836)	4.67 (934)
M3: 50% of above nutrients applied through fertigation and remaining 50% through soil application in the form of castor cake	5.20 (1040)	3.96 (792)	6.26 (1252)	5.14 (1028)
M4: 750 g N, 188 g P ₂ O ₅ , 188 g K ₂ O/plant applied through fertigation	2.92 (584)	1.86 (372)	3.20 (640)	2.66 (532)
M5: 50% of above nutrients applied through fertigation and remaining 50% through soil application in the form of neem cake.	2.90 (580)	3.06 (612)	2.94 (588)	2.96 (592)
M6: 50% of above nutrients through fertigation and remaining 50% through soil application in the form of castor cake.	0.88 (176)	3.40 (680)	3.52 (704)	2.6 (520)
M7: 500 g N, 125g P ₂ O ₅ , 125 g K ₂ O/plant soil application and separate drip irrigation.	3.14 (628)	3.34 (668)	3.98 (796)	3.48 (696)
M8: 750 g N, 188 g P ₂ O ₅ , 188 g K ₂ O/plant soil application and separate drip irrigation.	2.06 (412)	2.34 (468)	3.50 (700)	2.64 (528)
M9: 50% of M-7 through inorganic and 50% through organic (Neem cake) both soil application and separate drip irrigation.	1.16 (232)	1.18 (236)	1.70 (340)	1.34 (268)
M10: 50% of M-7 through inorganic (soil application) and 50% through organic (Castor cakes) both applied to soil and separate drip irrigation.	2.20 (440)	1.14 (228)	1.18 (236)	1.50 (450)
M11: 50% of M8 applied through inorganic and remaining 50% through organic in the form of neem cake both applied to soil and separate drip irrigation.	0.52 (104)	1.96 (392)	1.08 (216)	1.19 (238)
M12: 50% of above nutrients through drip irrigation and remaining 50% through soil application in the form of castor cake and separate drip irrigation.	1.76 (352)	2.74 (548)	2.18 (436)	2.22 (444)
M13: Control plot receiving no irrigation and fertilizers and organic manures				0.88 (176)
Mean	2.39 (478)	2.52 (504)	2.90 (580)	2.62 (524)
				CD
Main plot (m)				1.26
Sub plot(s)				NS
m x s				1.60

Figures within parenthesis indicate yield in kg/ha

Table 2.8: Influence of fertigation on yield kg/tree and kg/ha in Goa 11/6 a promising accession under in high density planting system

Main plot treatments	Sub treatments			Mean
	1	2	3	
M1: 250 g N, 62.5 g P ₂ O ₅ , 62.5 g K ₂ O/plant applied through fertigation	1.77 (1106)	1.55 (969)	1.56 (975)	1.62 (1012)
M2: 50% of above nutrients applied through fertigation and remaining 50% through soil application in the form of neem cake	1.87 (1169)	1.71 (1069)	2.01 (1256)	1.86 (1165)
M3: 50% of above nutrients applied through fertigation and remaining 50% through soil application in the form of castor cake	2.00 (1250)	2.14 (1350)	1.86 (1163)	2.00 (1254)
M4: 500 g N, 125 g P ₂ O ₅ , 125 g K ₂ O/plant applied through fertigation	1.72 (1075)	1.50 (938)	1.70 (1063)	1.64 (1025)
M5: 50% of above nutrients applied through fertigation and remaining 50% through soil application in the form of neem cake.	1.90 (1188)	1.69 (1056)	1.89 (1181)	1.83 (1142)
M6: 50% of above nutrients through fertigation and remaining 50% through soil application in the form of castor cake.	1.82 (1138)	1.67 (1044)	2.21 (1381)	1.90 (1188)
M7: 250 g N, 62.5 g P ₂ O ₅ , 62.5 g K ₂ O/plant soil application and separate drip irrigation.	2.15 (1350)	1.83 (1144)	1.11 (694)	1.70 (1063)
M8: 500 g N, 125 g P ₂ O ₅ , 125 g K ₂ O/plant soil application and separate drip irrigation.	1.95 (1219)	2.20 (1375)	2.31 (1444)	2.16 (1346)
M9: 50% of M-7 through inorganic and 50% through organic (Neem cake) both soil application and separate drip irrigation.	1.79 (1119)	1.44 (900)	1.78 (1113)	1.67 (1044)
M10: 50% of M-7 through inorganic (soil application) and 50% through organic (Castor cakes) both applied to soil and separate drip irrigation.	2.27 (1419)	1.80 (1125)	2.36 (1475)	2.15 (1340)
M11: 50% of M8 applied through inorganic and remaining 50% through organic in the form of neem cake both applied to soil and separate drip irrigation.	2.29 (1431)	2.43 (1519)	2.19 (1368)	2.30 (1439)
M12: 50% of above nutrients through drip irrigation and remaining 50% through soil application in the form of castor cake and separate drip irrigation.	2.43 (1519)	1.73 (1081)	2.19 (1369)	2.12 (1323)
M13: Control plot receiving no irrigation and fertilizers and organic manures	1.16 (725)	1.47 (919)	2.19 (700)	1.25 (781)
Mean	1.93	1.78 (1112)	1.12 (1162)	1.85 (1156)
	F Test	CD (0.05)	Sem +	CV (%)
M	**	0.48	0.23	26
S	NS	0.13	0.06	
M&S	**	0.62	0.30	15.

Main plot treatments : 1 to 13 - Fertilizer and manure application treatments
 Sub plot treatments : Three levels of irrigation 20, 40 and 60 CPE
 Figures in parenthesis : kg/ha

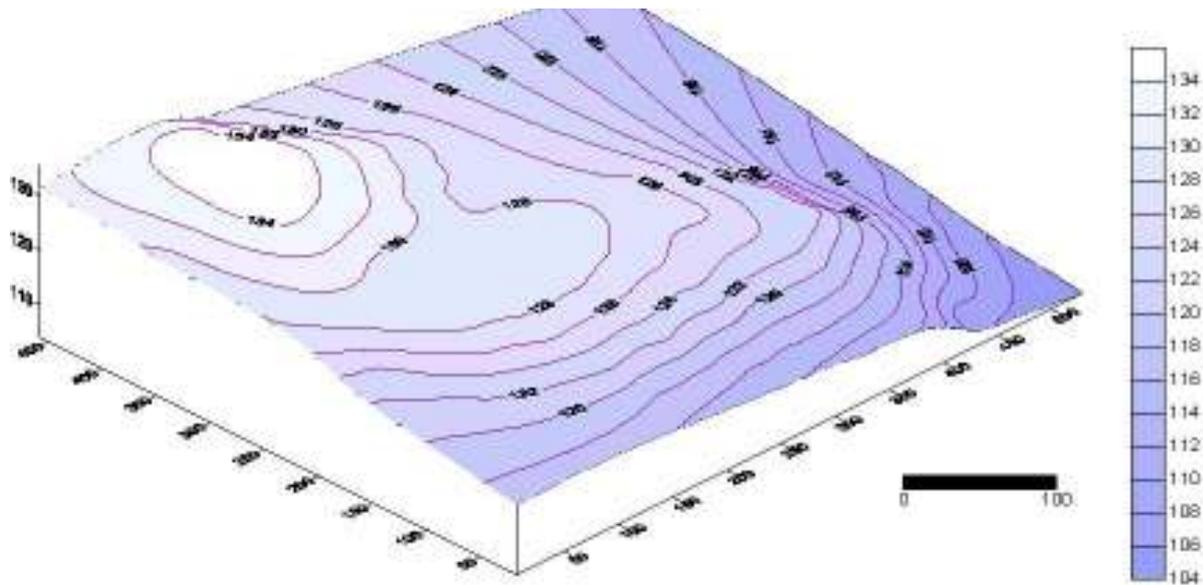


Fig.2.1
Contour map

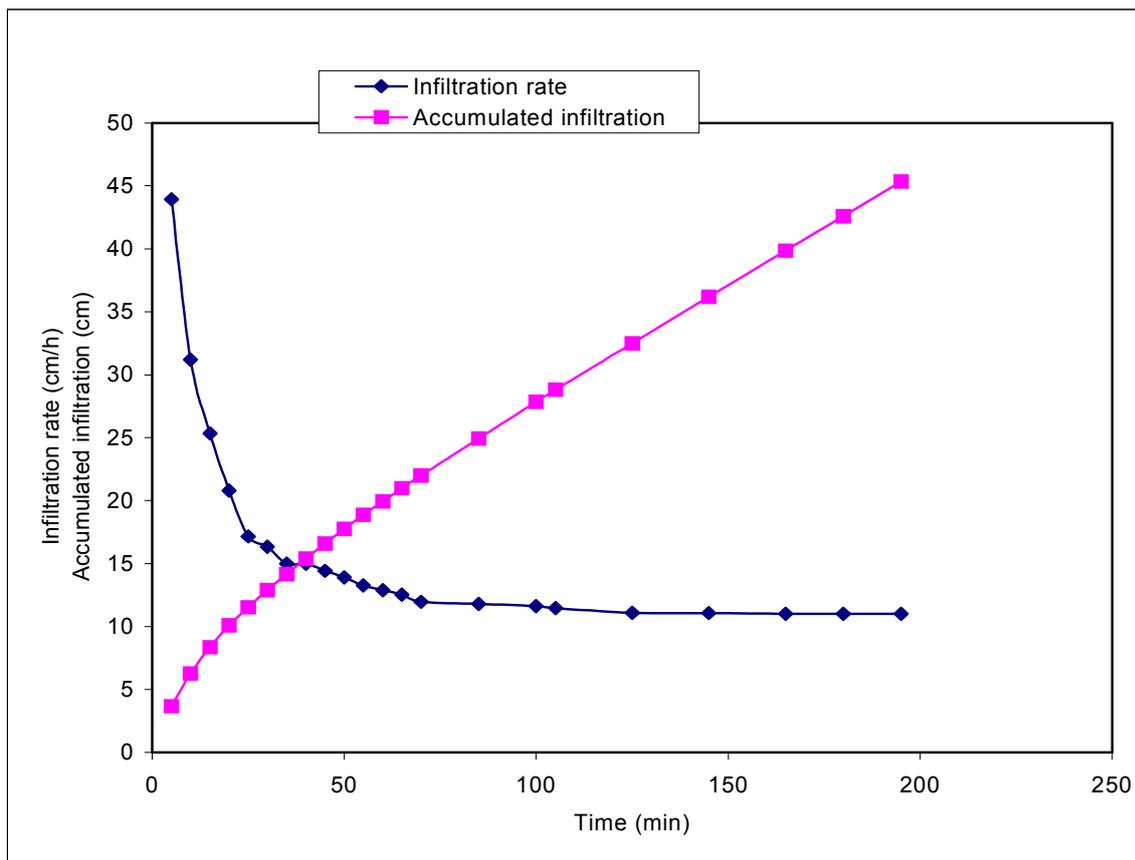


Fig.2.2
Average infiltration rate of the soil

3. CROP PROTECTION

3.1 Cashew Stem and Root Borer (CSRB)

3.1.1 Trials on ovipositional deterrence and residual toxicity

Under laboratory trials on ovipositional deterrence, sufficient number of oviposition twigs were sprayed with test insecticide to provide treated sticks for evaluation later at 1, 3, 5, and 7 days . Equal number of treated sticks were set aside for further evaluation . Two pairs of mated CSRB beetles were enclosed for oviposition on these pre-treated sticks in aerated oviposition boxes for a period of 48 h. after 1, 3, 5 and 7 days after treatment (DAT). The insect mortality and oviposition if any, were recorded after 48 h.

Egg laying was noticed in treated sticks when adult mated beetles were released on or after 5 DAT. Hatched CSRB grubs died upto 5 DAT, however, the nascent grubs could survive and develop normally on treated sticks from eggs laid on 9 DAT. Adult beetles died before 48 h, when released on treated sticks on 1 to 3 DAT (Table 3.1).

The eggs of CSRB were obtained from laboratory insect cultures and were used for field trials to evaluate the residual toxicity. Marked cashew trees were treated with test insecticide by spraying insecticide solution at different concentrations the bark surface at 3, 5, 7, 9 and 12 DAT. The CSRB eggs obtained from laboratory cultures were placed in the bark crevices and their location was marked with a coloured pin. The percent hatch and survival was recorded on 5th day after placing the eggs as mean egg period was 5 days.

The egg hatch was noticed on trees when eggs were placed on 3 DAT whereas, the grubs could not survive after hatching up to 5 DAT. Egg hatch and grub survival was normal from 7 DAT onwards. This indicated the non-systemic nature of the

insecticide and its breakdown under field conditions leading to non-toxicity to nascent grubs (Table 3.2).

3.1.2 Post extraction prophylaxis trials

The trials on post-extraction prophylaxis (PEP) have been initiated in NRCC plots and demonstration plots along with adoption of phytosanitation, wherein the trees with more than 50 per cent of bark circumference damaged or / and yellowing of the canopy has occurred were removed by uprooting. The trees having initial or moderate infestation were sequentially treated with test insecticides at different concentrations after removal of grubs and other stages of the pest. The duration for which no fresh incidence occurred and the percent of treated trees without reinfestation is recorded. The test insecticides were chlorpyrifos and monocrotophos at 0.2, 0.4 and 0.6 per cent. The phytosanitary measures were adopted by uprooting the trees beyond recovery (yellowing of canopy and / or > 50 per cent of bark circumference damaged). The level of fresh incidence during the subsequent season and the number of grubs per infested tree are recorded.

Monthly surveys were conducted to identify the indigenous natural enemies which infest the grubs of CSRB. The entomophagous fungus, *Metarhizium anisopliae*, was encountered in few grubs collected from severely infested trees. *M. anisopliae* was also noticed to grow saprophytically on the frass material in such trees.

Semi synthetic diet (SSD) was prepared using bengal gram flour as a base along with an antifungal antibiotic, Griseofulvin. Grubs of CSRB were reared on two SSDs with varying proportion of the host bark (6% and 10%). The grubs fed normally on both the diets. The growth and development of the grubs on these diets is compared with that in the host bark. The detailed biology and percent survival to adulthood are recorded compared to the CSRB grubs reared on host bark.

3.2 Tea Mosquito Bug (TMB)

3.2.1 Chemical control

3.2.1.1 Evaluation of new insecticides in large plot trial:

In the earlier trials, λ -cyhalothrin (0.003%), cartap (0.075%) were found to be equally effective with standard insecticides. This was again compared in a large plot trial (72 – 102 trees/plot) along with spray oil (1 ml/l) in an exploded block design. Three rounds of sprays were given in the first fortnight of December 2002, second fortnight of January and February 2003. The damage (0-4 scale) was assessed before each spray and one month after third spray. The total predatory population (spider, ants, mirid, reduviid and geocorid bugs, preying mantids and chrysopids) exiting on 52 panicles/tree was also recorded one month after third spray. The results were compared through paired 't' test. Carbaryl and λ -cyhalothrin treatments were found to be superior and cartap was found to be ineffective as it has scored TMB damage on par with untreated control. The total predatory fauna was highest in the cartap treated plot. As mealy bug infestation was noticed only in this plot, it might have enhanced total predatory fauna. λ -cyhalothrin treatment recorded least number of spiders (0.05 spider/panicle) than other treatments (0.18 – 0.40 spiders/panicle) but recorded highest population of predatory mirid bug (0.48/panicle) than other treatments (0.12 - 0.29/panicle). Previous studies have revealed that spider population has not reduced the incidence of tea mosquito bug in the unsprayed plots and its drastic reduction due to λ -cyhalothrin treatment may not cause any resurgence of TMB in case it is treated regularly with λ -cyhalothrin. Therefore, λ -cyhalothrin (0.003%) can be recommended for management of TMB as an alternative insecticide and it is also cheaper than carbaryl, already recommended insecticide (Table 3.3 and 3.4).

3.2.1.2 Evaluation of λ -cyhalothrin (Karate) in a larger plot:

Karate (0.003%) was sprayed in a large plot of 4 ha area (NRCC). During November 2002, commencement of outbreak of TMB was observed. In order to prevent the outbreak, three rounds of sprays were given during November,

December 2002 and January 2003 coinciding with flushing, flowering and fruiting stage. One month after third round of spray, 12 trees in a stratified random sampling were chosen. In each tree, remnants of damage at first flushing stages as pre-treatment damage and damage one month after third spraying as post-treatment damage were recorded simultaneously from 52 leader shoots of each tree. After first flush, if TMB damage occurred on a particular leader shoot, such leader shoot contained the lateral shoots either with remnants of withered damage lesions alone or sometimes along with dried leaves / dried panicles. Therefore, based on the remnants of damage, the pre treatment damage was backdated and post-treatment damage at existing condition was graded on a 0-4 scale simultaneously at a time in the respective leader shoot. The predatory fauna existing on available flowering panicles (10-33 panicles/tree) of above mentioned selected shoots were recorded by tapping method. One month after the last spray, gravid females of TMB were caged for 48 h on four trees at random for oviposition. The TMB eggs laid during above period were subjected to natural parasitism by egg parasitoids of TMB. Twenty days after caging, the shoots containing eggs were severed and sorted out in the laboratory under microscope to estimate the extent of parasitism. Simultaneously the eggs laid naturally were also collected from midribs of leaves and panicles and extent of egg parasitism was estimated.

In order to find out the activities of pollinators the plantation was observed continuously for three days after each spray. Further on the every next day of last spraying, the hermaphrodite flowers were collected at random during evening hours and examined under microscope to estimate the extent of insect pollination. The observations recorded on TMB damage, predatory fauna, etc, are presented in Table 3.5. The next three days after each round of spray, the plot was surveyed to find out the activities of pollinators. In general, the activities of pollinators were very low it is similar to untreated plot located elsewhere in Shantigodu. However, activities of sting less bee (*Trigona irridipennis*) was also observed in addition to activities of halictid bees and honeybees. The sting less bee collected both nectar and pollen from newly blossomed hermaphrodite flowers and loaded in the pollen basket of the legs as a slimy mass. The honeybees and butterflies collected nectar whereas, the

halictid bees collected both nectar and pollen. The hairs of hind legs of halictid bees were loaded only with pollen of cashew flowers. λ -cyhalothrin has prevented the outbreak of TMB effectively. The insecticide has not affected the activities of natural enemies of TMB except spider. Among predatory fauna, besides spiders and mirid bugs, except spider, geocorid bugs and ants were also commonly noticed. The extent of insect pollination (53.13%) was within the normal range of pollination (25.0 to 72.0%). Therefore this insecticide can be recommended in the place of carbaryl (0.1%) and monocrotophos (0.05%) (Table 3.5).

3.2.1.3 Seasonal incidence of TMB

In a unsprayed plot (Goa 11/6) at Shantigodu, 12 trees were marked at random and from each tree, 52 leader shoots were tagged and weekly population of TMB and its damage were recorded. This year the adjoining plot (V-4) that had high population of TMB was lopped off during first fortnight of November 2002. Because of this, there was rapid spread of TMB population to the neighbouring plot of Goa 11/6 which had commencement of flushing stage. As a result, the commencement of TMB damage was observed from second fortnight of November. But the build up of population in this plot was observed from first fortnight of December 2002. It reached peak during first fortnight of January 2003 and continued upto first fortnight of February 2003 and finally declined with least population during April. In total, the flushing and flowering stage was severely damaged resulting in severe loss in yield and it was quite different from previous years wherein fruiting stage is to be severely damaged during the course of outbreak.

3.3 Other studies

3.3.1 Confirmation of thrips damage on green apple cracking and corky nut:

The corky growth on the green apple always results in cracking of green apple before ripening. Therefore, in order to find out whether thrips damage is the main reason for green apple cracking and corky nut, the studies were undertaken to exclude thrips population. For this purpose, the flower panicles on first day of

commencement of flowering was tagged in NRCC-2 and such panicles were treated as dip treatment with contact cum systemic insecticide (monocrotophos 0.07%) at weekly interval for six weeks along with regular monthly spray with λ -cyhalothrin (0.003%) as the whole plot treatment. As such, those panicles were kept under complete protection against thrips damage for 56 days. In total 135 panicles of different sizes (short/puny and long/stout panicles) on seven trees were marked and treated. When the panicles had green nut stage (before dry nut stage), the green apples and nuts were observed for corky growth. The fruit set was seen on the 28 stout panicles of four trees only. While observing the fruits of tagged panicles in respective tree, the panicles having similar fruit set in the adjoining regions of same tree were also observed for corky growth as monocrotophos untreated panicles (Table 3.6).

Interestingly the results indicate that the corky growth was observed on nut and green apples of monocrotophos treated panicles similar to monocrotophos untreated panicles and it may be due to nutritional deficiency caused by boron deficiency. Therefore, detailed studies are required to diagnose this malady.

3.3.2 Studies on determination of insecticide residues in cashew kernels

3.3.2.1 Monitoring of different insecticides used in the management of cashew stem and borer (CSRB).

Monitoring of the residues of two insecticides recommended for the management of CSRB namely chlorpyrifos and lindane was done in the kernels samples collected from the treated trees. Both these insecticides were applied at 0.2% concentration as post treatment prophylaxis after the removal of grubs from the CSRB infested trees. Nut samples were collected at the time of harvest. The residue was not detected in any of the samples analysed at detection limit of 100 ppb for both the insecticides.

3.3.2.2 Determination of level of different insecticides used in the management of tea mosquito bug.

a) *Endosulfan*

At fruiting stage, cashew trees were sprayed with endosulfan at recommended concentration (0.05%) and double the recommended concentration (0.1%). The nut samples were collected on same day, 3, 7 and 14 days after treatment and the kernels were analysed for the residues. Residues were not detected in the kernel samples collected. Samples were also got analysed at Cashew Export Promotion Council of India (CEPCI) laboratory at Kollam. Residues were not detected in the analysis undertaken there.

b) *Carbaryl*

Carbaryl spraying was done at recommended concentration (0.1%) and double the recommended concentration (0.2%) to the cashew trees at fruiting stage. The residues was not detected in the kernel of the nut samples collected on same day 3, 7 and 14 days after treatment.

3.3.2.3 Documentation of levels of insecticides used in the management of cashew pests in other cashew

Rawnuts were collected from farmers' fields and from farm gates in maidan parts of Karnataka and Sindhudurg district of Maharashtra.. Analysis was done for the residues of insecticides used in the management of tea mosquito bug and cashew stem and root borers in the kernels. The residues of endosulfan, carbaryl, chlorpyriphos and lindane were not detected in the samples from farmers' field and farm gate. Samples were also been analysed at Cashew Export Promotion Council of India (CEPCI) Laboratory at Kollam. This analysis also revealed the absence of residues of insecticides in the kernels.

3.3.2.4 Estimation of residues of endosulfan in cashew eco-system

Spraying of endosulfan was done at recommended concentration (0.05%) to the cashew plot and the analysis for the residue was done in leaves, soil and weed biomass collected 3, 7 and 14 days after spraying in addition to the sample collected on the same day. The residue was not detected after 14 days of spraying indicating the low persistence of this insecticide in cashew eco-system.

3.3.3 Studies on pheromones of tea mosquito bug (*Helopeltis antonii* Sig.)

3.3.3.1 Electroantennogram response of male antennae

The response of antennae separated from male insects of different age groups towards extract of abdomen of virgin female, mated female and field collected female tea mosquito bug has been recorded. The response of 3 day old male antenna ranged from -0.276 mv to -0.434 mv. The response of 4 day old male antenna ranged from -0.413 mv to -0.798 mv. The response of 5 day old male antenna ranged from -0.285 mv to -0.418 mv for the various extracts. This was in comparison to -0.243 mv, -0.269 mv and -0.208 mv for dichloromethane alone showed by 3 day, 4 day and 5 day old male antennae.

3.3.3.2 Characterization of response inducing compounds:

Abdomen extract of virgin female (3 and 5 days) in dichloromethane was analysed by GCMS following Rembold's M method. The compounds with more than 90 per cent matching were toluene, cyclohexanol, 3-carene, dodecane, β -pinene, 1,2-benzenedicarboxylic acid, tetradecamethylcyclohepta siloxane, pentadecane, heptadecane, octadecane, trans-geraniol 2,6 octadien-1-0, 1- β -pinene bicyclo, 4-tert-butyl-1,2 benzenedithiol, and tetra deconoic acid methyl ester.

Table 3.1: Mean number of eggs deposited by CSRB in trials on ovipositional deterrence

Test insecticides	Mean number of eggs deposited					
	1 DAT	3 DAT	5 DAT	7 DAT	9 DAT	
					No. of eggs	% survival of grubs
Chlorpyriphos (0.2%)	0.00	0.00	3.83	5.83	6.83	81.74
Chlorpyriphos (0.4%)	0.00	0.00	2.00	1.83	5.17	77.36
Chlorpyriphos (0.6%)	0.00	0.00	1.00	1.50	3.67	70.71
Monocrotophos (0.2%)	0.00	0.00	2.83	7.67	7.50	72.71
Monocrotophos(0.4%)	0.00	0.00	1.50	8.17	8.17	69.40
Monocrotophos(0.6%)	0.00	0.00	1.17	8.33	7.33	64.41
Untreated Check	5.75	7.58	7.08	11.17	9.33	73.20

Table 3.2: Mean number of eggs hatched and mean no. of CSRB grubs survived in field trials due to residual toxicity.

Test insecticides	Days after treatment									
	5 DAT		7 DAT		9 DAT		12 DAT		15 DAT	
	% eggs laid	% grub survival	% eggs laid	% grub survival	% eggs laid	% grub survival	% eggs laid	% grub survival	% eggs laid	% grub survival
Chlorpyriphos (0.2%)	80.00	0.00	76.70	43.50	76.70	56.50	66.70	85.70	83.33	61.00
Chlorpyriphos (0.4%)	76.00	0.00	73.33	18.20	73.33	54.20	70.00	84.00	96.66	56.00
Chlorpyriphos (0.6%)	73.33	0.00	76.70	17.10	80.00	50.50	83.33	65.00	86.66	51.70
Monocrotophos (0.2%)	80.00	0.00	80.00	45.80	83.33	69.60	86.66	84.60	90.00	74.10
Monocrotophos(0.4%)	70.00	0.00	70.00	38.10	76.70	64.80	73.33	82.60	80.00	62.50
Monocrotophos(0.6%)	76.00	0.00	80.00	37.50	73.33	63.60	76.66	72.70	73.33	50.00

Table 3.3: Evaluation of promising insecticides in large plot trial.

Treatments	TMB damage on 30 DAT (0-4 scale)	Predators (No./panicle)			Cost of chemical/tree (Rs.)*	
		Spider	Mirid bug	Total	For single spray	For three sprays
Carbaryl 0.1% + spray oil	0.19 aA	0.18 aA	0.14 aA	0.39 aA	4.56	14.00
λ-cyhalothrin 0.003% + spray oil	0.22 aA	0.05 bB	0.48 bB	0.64 aB	1.91	6.00
Cartap – 0.075% + spray oil	3.58b B	0.40 bB	0.29 aA	0.79 bB	9.30	28.00
Untreated control	3.58 b	0.23 a	0.12a	0.47 a	-	-

*5 litre spray fluid / tree. DAT- Days after third spray.

Values in a column followed by small letter indicates the comparisons of untreated control versus respective chemical treatment and by capital letter indicates standard treatment (carbaryl) versus respective chemical treatment.

Values in a column followed by common letter of either untreated control or carbaryl are not significant by paired ‘t’ test at 5% level.

Table 3.4: Evaluation of insecticides against TMB in large plot trial – economic analysis.

Treatment	Yield (kg/tree)		Yield contribution due to insecticide (kg/tree) ^b	Gross profit (Rs/tree) ^c	Cost of insecticide application (Rs/tree) ^d	Net gain (Rs/tree) ^e	Grain from insecticide ^f	Benefit cost ratio
	Sample trees	Whole plot						
Carbaryl	3.98	2.88	1.71	101	22	79	38	2.73
Cyhalothrin	3.94	2.97	1.80	104	14	90	49	4.50
Cartap	2.12	2.27	1.10	79	36	43	2	1.06
Control	1.23	1.17	0.0	41	0	41	0	

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

b = Yield of the insecticidal treatment – yield of control

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

d = Cost of insecticides (Table 5) + cost of application

e = Gross profit – Cost of insecticide application

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

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

Table 3.5: Evaluation of Karate in a large plot.

Details	Mean \pm S.E	Range
TMB Damage (0-4 scale):		
i) Pre treatment	1.78 \pm 0.38	0.03 – 3.58
ii) Post treatment	0.23 \pm 0.07	0.01 – 0.88
Natural enemies fauna:		
i) Total predatory fauna (no./panicle)	1.08 \pm 0.24	0.29 – 2.75
ii) Spider (no./panicle)	0.04 \pm 0.02	0.0 – 0.13
iii) Mirid bug (no./panicle)	0.48 \pm 0.07	0.21 – 0.85
iv) Egg parasitism of TMB by HET (%)	63.75 \pm 4.61 (62.50)	51.79 – 74.29
Insect pollination:		
i) Hermaphrodite flowers with pollen deposit (%)	53.13	-
ii) No. of pollen grains/stigma	2.53 \pm 0.39	1 - 6

Figures in paranthesis indicate natural egg parasitism from field collected TMB eggs.
SE = Standard error

Table 3.6: Effect of monocrotophos on corky growth of green apple and nuts.

Tree no.	Total panicle	Monocrotophos treated panicles (no.)		Monocrotophos untreated panicles (no.)	
		Total apples/nuts	Apples/nuts with corky growth	Total apples/nuts	Apples/nuts with corky growth
1	14	20	8	15	8
2	3	3	0	2	1
3	6	8	1	10	7
4	5	7	5	7	5
Total	28	40	14	34	21

4. POST HARVEST TECHNOLOGY

4.1 Value addition in cashew

4.1.1 Studies on cashew testa crude fibre

Crude fibre isolated from whole and methanol extracted cashew kernel testa has been analysed for protein, carbohydrate, sugars, water absorption capacity and in vitro digestibility of protein and carbohydrate (Table 4.1). The crude fibre isolated from methanol extracted cashew kernel testa had lower carbohydrate content and higher extent of in vitro digestibility of carbohydrate and protein compared to crude fibre isolated from cashew kernel whole testa. Water absorption capacity of crude fibre from methanol extracted cashew kernel testa was higher (498.1 %) than that of crude fibre isolated from cashew kernel whole testa (544.9 %).

4.1.2 Studies on cashew apple pomace

Large quantity of cashew apple pomace was prepared for feeding trials with Japanese quails at ICAR Research Complex for Goa, Goa. Crude fibre has been isolated from cashew apple waste powder before and after growing *Pleurotus* on it collected from ICAR Research Complex for Goa and has been analysed for its composition (Table 4.2). Crude fibre extracted from cashew apple waste after growing *Pleurotus* on it had higher protein content and water absorption capacity and lower carbohydrate and per cent in vitro digestibility of protein compared to crude fibre extracted from cashew apple waste without growing *Pleurotus* on it.

4.2 Mineral composition of defatted cashew kernel flour of released varieties

Defatted cashew kernel flour of 28 released varieties of cashew has been analysed for P, K, Na, Ca, Mg, Fe, Mn, Zn, Cu and Se (Table 4.3). Defatted cashew kernel flour is rich in K and P. The content of Na, Cu, Zn, Mn, Cu and Se in the defatted cashew kernel flour is less compared to other minerals. Ratio of Ca/Mg and K/Na, varied in different released varieties and it ranged from 0.41 to 2.50 and 87.4 to 451.9

respectively indicating predominant presence of K. The variation in mineral composition noticed among different varieties could be due to differences in soil fertility as the nuts were collected from different locations. Variation noticed among different varieties collected from the single location could indicate the varietal variation.

4.3 Performance evaluation of small scale cashew nut processing units

Cashew processing machinery viz. vertical type direct steam boiler (40 kg raw cashew nut capacity) and electrically operated tray type kernel drier (25 kg kernel capacity) were optimized for its operational parameters. The moisture content of the raw nut samples was found to be in the range of 8.3 to 9.7 % d.b. showing that the nuts were well dried before supplying to processing line. In order to optimize nut conditioning parameters, the nuts were subjected to various steam pressure viz., 60, 70, 80 90 PSI for 7, 11, 15 and 19 minutes in different batches. After steam treatment, the nuts were cooled in ambient environment for 20 hours in thin layers. The conditioned nuts were shelled using hand cum pedal operated Sheller to extract the kernels. The shelled kernels were sorted based on its wholesomeness and analyzed for its qualitative efficiency. Kernels, thus extracted were subjected to hot air drying to enable skin removal carefully. After manual peeling, index was worked out based on end product value.

Kernel drying parameters were optimized by treating the nuts to predetermined steam i.e. 72 PSI for 14 minutes and shelled to extract whole kernels. Whole kernels were then exposed to hot air maintained at 60, 70, 80 and 90°C for 4, 6, 8 and 10 hours in different batches. At the end, the kernels were peeled manually using stainless steel knife engaging skilled personnel. The peeled kernels were sorted in to wholes, broken, rejects and hard to peel kernels and analyzed.

Product value method was attempted to evaluate the cashew nut processing machineries. Based on the index obtained and following optimization technique, the critical values at which better kernel grades could be obtained using steam boiler (40

kg raw nuts per batch) and kernel drier (25 kg kernel per batch) were worked out. Data revealed that the nuts could be conditioned at 70 to 75 PSI ($Y = -1.0031x^2 + 4.5378x + 1.0045$ with $R^2 = 0.9645$) for 13 to 15 minutes ($Y = -0.6729x^2 + 3.7451x + 1.1492$ with $R^2 = 0.8848$) in small scale steam boiling unit for maximum recovery of whole kernels in shelling. In the same way, extracted kernels could be exposed in hot air in electrically operated tray drier maintained at temperature in the range of 70 to 75°C ($Y = -37.862x^2 + 215.41x - 138.53$ with $R^2 = 0.9616$ for 6 to 7 hours ($Y = -13.241x^2 + 74.078x + 50.047$ with $R^2 = 0.9618$) to yield high value end product.

A detachable type LPG gas burner was fitted to steam boiler as thermal source. Experimental results with LPG burner revealed that the nut conditioning could be completed in half the time required in comparison to fire wood as heat energy with less expense on heat source. Moreover replacing with appropriate nozzle in burner assembly, bio gas could also be used. A movable platform suitable for steam boiler (40 kg capacity) was also developed for small scale facility to move from one place to another at farm level.

4.4 Economic feasibility of cashew nut processing units in Kolar district of Karnataka

Economic feasibility of on-farm or small scale cashew nut processing in Kolar district of Karnataka is worked out and the economics are projected. Cashew is produced to the tune of 5083 tones contributing 10.14 per cent of nut production in Karnataka state. Raw nuts produced are systematically marketed through Agricultural Produce Market Committee situated in Chintamani.

Presently, nuts are conditioned by steam boiling technique before shelling to recover kernels. Hand cum pedal operated Sheller is being used to extract kernels from conditioned nuts. Gas fired kernel drier is used in one of the cashew units to heat the entrant air. The temperature could be controlled by two-stage burner and hot air is circulated at a constant low speed to maintain uniform temperature throughout

drying process. After manual peeling of kernels at home level, graded based on colour and wholesomeness and packed using polythene bags. Kernel market in Mangalore district serves as benchmark to fix up price of kernel supplied from this region.

Comparative economic feasibility of existing method and small-scale processing reveals that based on the production of raw cashew nuts in this region, about 79 units could be started with the utilized capacity up to 64 TPA i.e. 320 Kg per day. Introducing small-scale processing units can increase the number of units to 635, generating employment to 3177 personnel which is twice more than the employment generation with the existing set up for the total raw nut production.

As the production efficiency at various stages of operation in the current system is inferior, in spite of higher capacity utilization i.e. 64 TPA, the unit weight value addition is worked out to be Rs 9.55 / kg of raw nuts against Rs. 11.05 kg in the case of small-scale processing system with operational capacity of 8 TPA. Inefficient technical and management aspects are the due reasons for the lower economic return.

Table 4.1: Chemical composition of crude fibre of cashew kernel testa and cashew apple waste (%)

Constituents	Whole testa	Methanol extracted testa	Cashew apple waste	
			A	B
Protein (N x 6.25)	7.96	8.53	10.94	23.55
Carbohydrate	14.41	8.93	12.29	5.37
Sugars	0.106	0.133	0.080	0.062
In vitro digestibility of				
Carbohydrate*	0.065	1.831	ND	ND
Protein	14.32	15.87	20.27	14.06
Water absorption capacity	498.1	504.9	220.70	265.70

A - Crude fibre from cashew apple waste after fermentation.

B - Crude fibre from cashew apple waste after fermentation and growing pleurotus on it.

ND - Not Detected

* - Expressed as mg maltose released/3h/100 mg

Values are mean of three individual estimations

Table 4.3: Mineral composition of defatted cashew kernel flour of released varieties.

Source	Variety	P	Na	K	Ca	Mg	Cu	Zn	Mn	Fe	Se	Ca/Mg	K/Na
NRCC (Shantigodu)	Ullal-1	0.884	6.49	749.9	36.40	32.27	4.34	4.72	6.42	13.21	13.77	1.13	115.5
	Ullal-3	0.462	5.15	802.3	13.00	31.55	2.94	4.06	3.24	8.90	3.49	0.41	155.8
	Ullal-4	0.558	5.38	746.4	34.10	31.81	3.53	3.84	5.40	10.28	3.29	1.07	136.7
	Selection-2	0.877	6.67	803.7	13.44	31.99	2.47	3.07	5.99	8.22	3.36	0.42	120.5
	Chintamani-1	0.754	7.85	750.7	25.24	31.81	7.24	4.11	5.86	10.27	3.26	0.79	95.6
	K-22-1	0.875	5.59	752.5	38.80	32.62	5.34	3.83	6.03	10.46	3.39	1.19	134.6
	Bla-39-4	0.903	4.46	750.0	35.17	32.00	3.25	3.69	4.65	12.48	7.59	1.10	168.2
	NDR-2-1	0.605	3.53	691.6	27.82	32.00	3.59	3.42	4.39	6.76	3.56	0.87	195.9
	V-1	0.763	3.19	737.2	28.34	31.92	4.11	3.44	2.62	8.26	3.20	0.89	231.1
	V-4	0.724	5.70	662.9	42.81	31.12	2.76	3.58	4.57	7.65	2.86	1.37	116.3
	V-7	0.893	5.50	785.6	43.12	31.69	2.27	4.21	3.83	11.58	2.54	1.36	142.8
	Dhana	0.770	3.12	700.2	14.23	29.84	2.83	3.30	3.79	9.26	6.05	0.47	224.4
Kanaka	0.823	4.80	714.2	44.29	31.88	3.46	3.83	4.92	8.17	7.27	1.39	148.8	
NRCC (Kemminje)	BPP-4	0.615	7.26	751.5	34.09	32.12	3.16	3.62	12.50	8.42	3.10	1.06	103.5
	BPP-6	0.594	7.27	652.0	36.60	32.05	3.96	4.00	12.66	7.70	3.20	1.14	89.68
	BPP-8	0.633	6.99	752.7	39.47	30.92	3.66	4.01	5.52	9.80	3.41	1.27	107.68
	Bhubaneswar-1	0.545	8.88	661.4	74.51	30.83	3.81	3.79	7.67	7.63	2.70	2.42	74.4
	Goa-1	0.304	7.27	650.2	20.91	30.92	2.82	3.33	5.09	7.07	1.99	0.68	89.4
	Jhargram-1	0.873	5.78	773.0	55.52	32.11	2.49	3.41	6.88	7.79	3.71	1.73	133.7
	VRI-3	0.536	4.42	615.1	30.54	30.32	2.22	2.97	3.23	7.13	2.69	1.00	139.2
ARS, Ullal	Priyanka	0.900	6.79	698.4	29.66	30.26	2.56	3.82	8.24	8.11	2.59	0.98	102.8
	UN-50	0.782	8.03	702.0	30.28	30.23	2.50	3.99	6.70	11.05	2.41	1.00	87.4
AICRP on Cashew													
Bapatla	BPP-9	0.956	9.08	781.6	24.49	31.36	5.51	4.46	5.41	9.46	3.21	0.78	86.1
Madakkathara	Akshaya	0.891	3.99	682.9	30.70	31.74	4.67	4.42	5.83	8.02	1.54	0.97	171.1
	Amrutha	1.028	2.03	754.9	26.73	31.46	2.52	4.46	6.45	8.79	2.39	0.85	371.9
	Anagha	0.951	1.58	714.1	28.21	30.96	2.67	4.44	7.50	11.24	0.98	0.91	451.9
	Sulabha	0.979	4.39	771.1	28.02	31.41	4.63	4.83	7.32	13.29	2.61	0.89	175.6
	Dhaarshri	0.987	3.97	732.4	33.11	31.48	4.07	4.49	7.83	10.74	8.79	1.05	184.5

All the values are expressed as µg/100 mg except P which is expressed as mg/100 mg.

Values are mean of three individual estimations.

5. TRANSFER OF TECHNOLOGY

5.1 Establishment of model cashew clonal gardens

In order to select new demonstration plots for demonstration of improved cashew cultivation practices under the Central Sector Scheme for Cashew Development, a total of 20 plots in D.K. district were visited for assessing suitability of the plots for taking up new demonstration. Out of these 20 plots, 17 plots were established by the respective newly selected demonstration farmers. Out of these 17 plots, 15 plots were laid out under high density planting (6m x 4m spacing) whereas, remaining two plots were laid out under hedge row system of planting (10 m x 5 m spacing) to accommodate intercrops viz., coccum and banana etc. Ullal-1, Ullal-3, NRCC Selection-2 and Goa 11/6 were distributed to the demonstration farmers for planting. The newly selected demonstration farmers were imparted training on improved aspects of cashew cultivation on ICAR Foundation Day. A total of 30 old and newly selected demonstrated farmers attended the training programme.

5.2 Organizing thematic campaigns

Two, thematic campaigns on SWC measures, high density planting and pruning in cashew were organized at Kavu and Keyyur villages of Puttur taluk. Intensive training on the above said aspects were imparted to the farmers through lecture-cum-demonstration, exhibition, literature and slide show. A total of 120 farmers imparted training in these two campaigns.

Two more thematic campaigns on 'Cashew cultivation' and 'Plant protection' were organized in collaboration with SKDRDP, Puttur at Panaje and Easwaramangala villages of Puttur taluk. A total of 200 participants were imparted intensive training on the above said subject through lecture-cum-discussion, slide show and exhibition modes.

5.3 Cashew Day

Cashew Day was organized on 19th March 2004 at Experimental Station, NRCC, Shanthigodu. The theme of the programme was ‘Cashew Based Cropping System’. with focus on profitability of cultivating other crops like vanilla, kokum, turmeric, pineapple, ginger in cashew orchards and high density planting system of cashew, so that the farmers can be motivated towards cashew cultivation. More than 150 farmers participated.

During Cashew Day, a field visit was arranged for the participants to a progressive farmer’s plot located at Sarve, Puttur where Ullal-1, Ullal-3, Ullal-4, Vengurla-3, Vengurla-4, Vengurla-7, NDR-2-1, K-22-1 are being grown under high density planting system and to some of the experimental plots at NRCC, Shanthigodu. The farmers were also explained about Japanese and Vermicomposting of recyclable cashew biomass (RCB) and spraying against insect pests of cashew. The farmers were convinced about the performance of the various cashew varieties to which they were exposed and the results of the experiments in the plots which they visited. An exhibition was also organized for the benefits of farmers participated. A special seminar was organized for the benefit of the participants. During the seminar the following topics were discussed.

i)	Mr. Ananda Rai Progressive farmer	High density planting in cashew
ii)	Dr. V. Krishnamoorthy Varanasi Research Foundation	Feasibility of growing vanilla in cashew plantation
iii)	Dr. N. Yadukumar NRCC, Puttur	Cashew based cropping systems
iv)	Dr. M. Appa Rao DCCD, Kochi	Cashew development programmes of DCCD

The seminar was followed by a question and answer session wherein doubts raised by farmers were cleared by resource persons. A total of 160 farmers participated in this programme.

5.4 Impact of transfer of technology in cashew cultivation

5.4.1 Impact of Cashew Day

The knowledge level and adoption behaviour of the farmers who attended the cashew day / field day was quite low against all the recommended cashew cultivation practices compared to that of demonstration farmers. It could be explained that such programmes are only to create awareness among more number of farmers about the recommended technologies and hence the adoption behaviour of these farmers observed are low.

5.4.2 Reasons responsible for the yield gap in cashew and suggestions to refine the extension modes (Farmers' response)

Climatic conditions mainly cloudy weather, non adoption of recommended practices, tea mosquito attack during the flowering and fruiting seasons, below average performance of the cashew varieties, attack of CSRB, theft problem during harvest, irregular flowering and poor soil fertility were some of the reasons responsible for the yield gap as quoted by farmers. Explaining the technologies through method demonstration, more number of visits to the demonstration plots during the seasons, more extension programmes at farmers' plots, more number of displays about the control of CSRB, maximum time allotment for discussion during the programmes and explaining the technologies through video show, more number of displays for exhibition, more time for visit to experimental / progressive farmers plot, keeping displays at respective fields and use of local language at extension programmes were some of the suggestions told by the farmers to refine the extension modes.

5.4.3 Constraints in adopting recommended cashew cultivation practices, reasons for yield gap in cashew

Lack of knowledge about improved recommended practices, small and marginal cashew growers who cannot afford to management practices with less productivity, drought, pest damage etc were the constraints in adopting recommended cashew cultivation practices by the farmers as told by researchers /extension personnel. Non-use of grafted planting material, recommended fertilizers, control measures against TMB and CSRB, senile and unproductive cashew gardens, no organized support for cashew replanting, insufficient extension programmes in cashew, farmers treat this crop as neglected crop and unpredictable pest outbreak etc were some of the reasons for yield gap in cashew as told by researchers / extension personnel.

5.4.4 Suggestions to overcome the constraints (Response from researchers / extension personnel)

Identification of resistant varieties against cashew pests, support for irrigation in cashew, organizing more thematic campaigns, popularizing the small scale processing units for value addition and employment generation training programmes at interior villages to educate economically backward cashew growers and larger area demonstration of popular cashew varieties are the suggestions offered by the extension workers / researchers to overcome the constraints faced by the farmers and yield gap in cashew.

5.5 Training Programmes

5.5.1 Training programme on “Vegetative Propagation of Cashew”

5.5.1.1 Training programme for development department officials

Two days training programmes on “Vegetative Propagation of Cashew” was organized. A total of 12 trainees sponsored by Development Departments viz., DOH, Karnataka (7), GFDC Ltd (2), KSFC Ltd (2) and KCDC Ltd (1) were imparted training on softwood grafting technique for multiplication of cashew varieties and nursery management techniques through participatory training (Table 5.1).

5.5.1.2 Training Self-Help Group Members on Vegetative Propagation of Cashew

A day long training programme was organized for the members of Self-Help Groups organized by SKDRDP, Puttur. A total of 22 such participants were imparted training on softwood grafting technique for multiplication of cashew varieties and nursery management techniques through participatory training (Table 5.1).

5.5.2 Training on ‘Pruning and Top Working in Cashew’

Rejuvenation of old gardens is one of the important measures to increase the production of cashew. Pruning of cashew trees and top working of the trees of seedling origin are such rejuvenation techniques. Two training programmes on ‘Pruning and Topworking on Cashew’ were organized for the field staff of Karnataka Cashew Development Corporation Ltd. (KCDC Ltd.), Mangalore (Table 5.1). The field staff of KCDC Ltd were imparted training on Pruning in Cashew, horticultural aspects of top working in cashew in cashew and entomological aspects of top working in cashew through lecture-cum-slide show, discussion, field visit to experimental plots and method demonstration.

5.5.3 Training programmes on ‘Cashew Production Technology’

- A special training programme on ‘Cashew Production Technology’ was organized for the officials of Development Departments in North-Eastern States. A total of 19 officials sponsored by Department of Agriculture (DOA), Assam, Department of Horticulture, Manipur and Meghalaya were imparted training on various advances in cashew cultivation for five days (Table 5.1).
- A refresher course on ‘Cashew Production Technology’ was organized for Development Departments officials belonging to various cashew growing states. A total of 31 trainees were imparted training on improved cashew cultivation aspects.
- A special course on “Cashew Production Technology” was organized for Development Officials of DOH, Tamil Nadu (20). The officials were provided training on improved aspects of cashew cultivation for 5 days.

5.6 Analysis on availability of planting material in approved cashew nurseries

An attempt was made to analyse data on the availability of planting material at various approved nurseries.

- The response from the East Coast nurseries are significantly lesser than the West Coast nurseries. The response from the private nurseries was overwhelmingly more than the response from government nurseries both in East and West Coast regions. This is due to the commercial orientation of the private nurseries (Table 5.2). But government nurseries also should come forward to popularize their planting material availability to distribute quality planting material to the needy farmers.

- The overall response is declining. This may be due to the growing demand from the farmers, so that it makes no need for many of the nurseries who produce less number of cashew grafts to popularize the planting material availability. So only nurseries which multiply larger number of planting material, have been responding.
- The number of cashew grafts multiplied by the East Coast nurseries are comparatively less than that of the West Coast nurseries. Hence DCCD, Kochi may provide financial aid for opening more private / government nurseries in East Coast region, vowing to the growing demand for production of raw cashewnuts.
- Number of non-recommended varieties of the respective states are being multiplied in states viz., Tamil Nadu, Karnataka, Orissa, Kerala and Goa by either private or government nurseries (Table 5.3). So the performance of these varieties in the non-recommended states should be studied based on the stakeholders point of view.
- Few varieties which are recommended for respective states are not being multiplied by either private / government nurseries (Table 4). These varieties may be popularized by the development departments and DCCD, Kochi in their respective states based on the performance of these varieties.

Table 5.1: Details of training programme organized

Date	Training Programme	Sponsored by
20-21, Aug., 03	Vegetative Propagation of Cashew	DOH, Karnataka (7); KSFC Ltd (2); KCDC Ltd (1); GFDC Ltd (2)
19 Sept., 2003	Vegetative Propagation of Cashew	SGH members of SKDRDP, Puttur (22)
7-8, Oct., 03	Pruning & Top working in Cashew	KCDC Ltd (30)
4-5, Nov., 03	Pruning & Top working in Cashew	KCDC Ltd (30)
17-21, Nov., 03	Special training on 'CPT'	DOA, Assam (12); DOH, Manipur (3); DOH, Meghalaya (4)
21-23, Jan., 04	Refresher training on CPT	ITDA, AP (15); DOH, Manipur (3); SKDRDP, Dharmasthala (3), DOA, Kerala (2); DOH, Maharashtra (7); BIRD, Tiptur (1).
16-20, Feb., 04	Special training on CPT	DOH, Tamil Nadu (20)

Table 5.2: Year-wiser, State-wise and sector-wise number of grafts posted into the NRCC website

Year	Sector	States									Grand total
		East Coast				West Coast					
		Tamil Nadu	Andhra Pradesh	Orissa	Total	Karnataka	Kerala	Maharashtra	Goa	Total	
2001-02	Govt.	-	-	-	-	63,000	1,21,000	-	-	1,84,000	1,84,000
	Private	51,300	-	75,000	1,26,300	3,31,574	50,000	5,85,923	5,18,000	14,85,497	16,11,797
2002-03	Govt.	-	235	-	235	55,227	10,000	36,600	-	1,01,827	1,02,062
	Private	-	-	-	-	-	78,000	2,25,000	5,14,000	8,17,000	8,17,000
2003004	Govt.	-	-	-	-	1,15,000	45,900	-	-	1,60,900	1,60,900
	Private	35,000	-	15,000	50,000	2,90,000	1,10,000	3,30,000	4,52,000	11,82,000	12,32,000
	Total	86,300	235	90,000	1,76,535	8,54,801	4,14,900	11,77,523	14,84,000	39,31,224	41,07,759

Table 5.3: Comparison between recommended and multiplied & distributed cashew varieties by approved nurseries. (Based on the pooled response from approved nurseries)

Sl. No	States	Recommended varieties	Recommended varieties multiplied & distributed by		Non-recommended varieties multiplied & distributed by		Recommended varieties not multiplied and distributed by	
			Govt. Nurseries	Private Nurseries	Govt. Nurseries	Private Nurseries	Govt. Nurseries	Private Nurseries
A. East Coast								
1.	Tamil Nadu	VRI-3 (1)	-	VRI-3 (1)	-	VRI-1, VRI-2, VRI-4 (3)	-	-
2.	Andhra Pradesh	BPP-4, BPP-6, BPP-8 (3)	BPP-4, BPP-6, BPP-8 (3)	-	-	-	-	-
3.	Orissa	Bhubaneswar-1, BPP-8, Dhana (3)	-	Bhubaneswar-1, BPP-8, Dhana (3)	-	Ulla-1, Ulla-3, VRI-2, VRI-3, Priyanka (5)	-	-
B. West Coast								
1.	Karnataka	Selection-2, Ullal-1, Ullal-3, Ullal-4, UN-50, V-1, V-4, V-7, Chintamani-1 (9)	Ullal-1, Ullal-2, Ulla-3, Ulla-4, UN-50 (5)	Selection-2, Ullal-1, Ulla-3, Ulla-4, V-1, V-4, V-7 (7)	NDR-2-1, Kanaka, V-3 (3)	VRI-2, VRI-3, BPP-8, Priyanka, Kanaka, Dhana (6)	Chintamani-1 (1)	Chintamani-1 (1)
2.	Kerala	BLA-39-4, NDR-2-1, K-22-1, Kanaka, Dhana, Priyanka, amrutha, VRI-3 (8)	BLA-39-4, NDR-2-1, K-22-1, Kanaka, Dhana, Priyanka, VRI-3 (7)	BLA-39-4, NDR-2-1, K-22-1, Kanaka, Priyanka, Dhana, Amrutha (7)	M-10-4, M44-3, V-1, V-4, K-10-2, Dharashree, Ullal-3, H-1600 (8)	-	Amrutha (1)	VRI-3 (1)
3.	Maharashtra	V-1, V-4, V-6, V-7 (4)	-	V-1, V-4, V-6, V-7 (4)	-	-	-	-
4.	Goa	Goa-1, V-1, V-4, V-6, V-7 (5)	-	V-4, V-7 (2)	-	Goa 11-6 (1)	-	V-1, Goa-1, V-6 (3)

Figures in the parentheses indicate the number of varieties

6. COMPUTER APPLICATION

6.1 Forecasting of cashew yield

Forecast of cashew production is needed by the Govt, agro-based industries, traders and agriculturist alike. It is imperative to have such data structure to make policy decisions by the GOI in regard to procurement, distribution, import-export. Price fixation and marketing alike. It also serves as a basic tool to plan the various operations for agrobased industries, trades and the agriculturists. Based on the existing forecasting model the estimated yield for 2003-04 is calculated (Table 6.1).

6.2 Database on cashew information

User friendly and menu driven cashew database has been developed in Visual Basic as a front end tool and Microsoft Access as a back end tool. The database tables were developed using normalization techniques to store data in systematic way and to avoid duplication of data. A total of 39 user interface forms were developed. All these forms are interlinked with each other. A total of 28 data reports were developed for this database. Out of these, 23 reports are dynamic data reports. These reports provide both numerical and graphical information. Based on the user request queries data reports can be generated. This package is fully menu driven. The main menu provides options like data entry, data modification/deletion and user query reports. Under data entry option, different forms provide different type of data entry like world production, country-wise production, state-wise production, import of raw nut from different countries, export of cashew kernels from India and world by country-wise and also export of CNSL. By using data modification/deletion option, user can update or delete the existing information on above aspects. The report option provides different types of data reports based on the user queries. The output data reports can be obtained in both numerical and graphical mode.

Table 6.1: State wise estimated cashew production

State	Production (M.T)
Andhra Pradesh	96,269
Goa	38,085
Karnataka	46,288
Kerala	1,08,302
Maharashtra	90,265
Orissa	52,760
Tamil Nadu	89,420
West Bengal	7,220
Others	5,547
Total	5,34,156



CONCLUDED PROJECTS

7. Concluded Project

7.1: Network Programme on Hybridization in Cashew

Principal Investigator	Dr. M.G. Bhat
Co-Principal Investigator	Dr. K.R.M. Swamy
Main Centre	National Research Centre for Cashew, Puttur
Collaborating centers	:
	a) Cashew Research Station (OUAT), Bhubaneswar, Orissa
	b) Agril. Research Station (UAS), Chintamani, Karnataka
	c) Cashew Research Station (KAU), Madakkathara, Kerala
	d) Regional Fruit Research Station (Dr.BSKKV), Vengurle, Maharashtra
	e) Regional Research Station (TNAU), Vridhachalam, Tamil Nadu
Project Number	: Adhoc Scheme
Project Duration	: 3 years (Nov. 2000 – Oct.2003)

7.1.1 Introduction

It was found that in the cashew growing states where both selections and hybrids of cashew were developed and released for cultivation, the performance of hybrids for yield was better than the selections. Hybrid vigour can easily be commercially exploited in cashew because of the amenability of this crop for vegetative propagation (by softwood grafting technique).

The "*per se*" performance of some of the cashew accessions may not be that impressive. But the hybrids produced, on crossing these accessions with other accessions / genotypes, may be superior to both the parents for yield and other economic characters. So it was felt that it would be highly

desirable to produce large number of cashew hybrids from the cashew germplasm accessions available in National Cashew Gene Bank (NCGB) and Regional Cashew Gene Banks (RCGBs) and test these hybrids in evaluation trials. The scheme sanctioned by ICAR was in operation for a period of three years with a total budget outlay of Rs.2,57,400/-, at NRCC, Puttur and five centres of AICRP on Cashew as collaborating centres (Bhubaneswar, Chintamani, Madakkathara, Vengurle and Vridhachalam), with a annual budget outlay of Rs. 85,800/-.

7.1.2 Objectives:

- i) To identify parents from cashew gene banks for hybridization
- ii) To produce large number of hybrid nuts by hybridizing chosen parents from germplasm and to collect hybrid nuts for sowing.

7.1.3 Material and Methods:

7.1.3.1 Choice of parents

The parents are chosen for the purpose of crossing based on the genetic diversity, yield, nut weight, cluster bearing habit, place of origin, RAPD data, complementary characters between the two parents of a particular cross-combination etc. during the crossing seasons 2000-01, 2001-02, 2002-03 in main centre at Puttur (NRCC) and collaborating centers at selected centers of AICRP Cashew.

7.1.3.2 Pollination

Large number of cross-combinations was made from the chosen parents at NRCC and collaborating centers during the three crossing seasons by engaging skilled persons for two months during the crossing seasons. Hybrid nuts were collected. Hybrid seedlings raised from this scheme were field planted either in the same year or next year.

7.1.4 Results

The details of the parents involved, cross combinations made, no. of pollinations effected, mature hybrid nuts obtained in three crossing seasons at six centres are given in Table 7.1.

Pollination work was carried out in 1294 cross-combinations involving 612 diverse parents by engaging skilled persons for pollinating for a period of two months during each of the three crossing seasons ie., 2000-01, 2001-02 and 2002-03 at six centers. A total of 1,42,255 pollinations were effected and 13,773 mature hybrid nuts could be obtained during the scheme period of three seasons covering all the six centers.

Hybrid nuts were sown in polybags and hybrid seedlings were raised in respective centers. The hybrid seedlings were field planted either in the same year or next year.

7.1.5 Conclusions

Large number of hybrids have been produced under this ad-hoc scheme and field planted at six centers. On evaluation of the large number of hybrids produced from diverse parents, it is likely that a few promising hybrids will be identified.

Table 7.1: The details of parents involved, cross-combinations made, number of pollinations effected, mature hybrid nuts obtained by different centers during three crossing seasons.

Centre	No. of Parents				No. of cross combinations made				No. of pollinations effected				No. of hybrid nuts obtained			
	2000-01	2001-02	2002-03	Total	2000-01	2001-02	2002-03	Total	2000-01	2001-02	2002-03	Total	2000-01	2001-02	2002-03	Total
NRCC, Puttur	65	42	76	183	65	213	96	374	11321	11327	7345	29993	251	623	405	1279
CRS, Bhubaneswar	22	11	17	50	19	20	70	109	6453	9783	9500	25736	461	730	1010	2201
ARS, Chintamani	30	18	37	85	51	63	56	170	7419	6445	3899	17763	957	800	898	2655
CRS, Madakkathara	37	31	63	131	17	35	173	225	3445	1705	16699	21849	180	169	1158	1507
RFRS, Vengurle	27	49	22	98	89	121	105	315	14448	14309	5584	34341	2202	2577	724	5503
RRS, Vridhachalam	28	18	19	65	33	36	32	101	5400	1457	5716	12573	301	65	262	628
Total	209	169	234	612	274	488	532	1294	48486	45026	48743	142255	4352	4964	4457	13773

7.2: Crop regulation in cashew through plant growth regulators

Project Leader	:	Dr. M. Gangadhara Nayak (2001-2003)
Project Associate	:	Dr. K.R.M. Swamy (2001-2003)
Project Number	:	2.10
Project Duration	:	3 years (2001-2003)

7.2.1 Introduction

Few cashew varieties released earlier for cultivation are poor yielders. Varieties like VRI-1 has prolonged flowering period with predominant male phase. Since, the grafts have been planted on a large area there is an urgent need to improve the yield performance of such variety as the variety also suffers from fruit drop at various stages of fruiting resulting in low yield. Thus, with the proven plant growth regulators for enhancing sex ratio, fruit set and nut retention and thereby, increasing yield the various growth regulators at different concentration were tried at flushing, flowering and fruiting stage.

The varieties such as Ullal-2 and VRI-2 were withdrawn because of their low nut weight, though they are prolific yielders. The practice of fruit thinning in several fruit crops has helped in improving the size of the produce. With the idea of enhancing the nut size fruit thinning by various chemical fruit thinners, the studies were initiated in existing seven year old plants of Kanaka variety.

7.2.2 Objectives

- i) To study the effect of various growth regulators on sex ratio, fruit set and nut retention in cashew (VRI-1).
- ii) Studying the possibility of improving the nut size by fruit thinning with chemical fruit thinners.

- iii) Standardization of application schedule of growth regulators to various cashew varieties.

7.2.3 Material and methods

7.2.3.1 Experiment 1: Improvement of sex ratio, fruit set and nut retention in cashew

The existing cashew plantations of VRI-1 planted during 1989-90 were utilized for the study.

The proven growth regulators for improvement of sex ratio, fruit set and nut retention were tried at different concentrations.

The sprays were given at flushing, flowering and fruiting stages (December, January, February months). Each treatments was replicated four times. Five panicles each in a tree were tagged and observed for various parameters and bisexual flowers by destructive sampling. Also the no. of fruits set and fruit drop was observed at weekly intervals. The final retention was observed at the time of full maturity. The volume of the 10 apples and 10 nuts was recorded. The yield/plant was recorded at weekly intervals.

7.2.3.2 Experiment 2: Enhancement of nutsize in small nut type by chemical fruit thinning

The existing five year old cashew plants of Kanaka were utilized for the study. The variety is a prolific bearer with 15-25 nuts per panicle with an average nut weight of 5-6 g.

The spray was given at peak fruiting period (February in both the years) Each treatment was replicated five times. The total number of fruits set, no. of fruits dropped, the no. of fruits retained and the yield/plant was recorded at weekly intervals. Volume of the nut and apple were recorded by water displacement.

7.2.4 Results

7.2.4.1 Improvement of sex ratio, fruit set and nut retention

The growth regulators were sprayed at flushing, flowering and fruiting (fruit development stage). Observations on sex ratio, fruit set and nut retention per panicle were recorded.

Observations on male and bisexual flowers indicated the dominant male phase continued to exist in early flowering season irrespective of growth regulator treatments. The male and bisexual flower count at different period had no significant effect on sex ratio (Table 7.2). Similarly fruit-set or nut retention were not affected by growth regulators. The growth regulator 2,4-D applied thrice showed phytotoxic effect on cashew plants. The results indicated that the growth regulators at various concentrations are not helpful in changing flowering and fruiting habit of genetically poor yielders.

7.2.4.2 Chemical fruit thinning for enhancement of nut size

The growth regulators were applied at peak fruiting stage and each treatment was replicated five times. Five panicles in each tree were tagged and observations were recorded.

The observations on number of fruits set, premature drop and nut retention revealed that the various chemical fruit thinners at lower concentration are not capable of bringing down fruit drop (Table 7.3). Ethrel at 150 ppm caused fruit shrivelling and drop during 2002 season. As the variety does not give the nut set at a time, the chemical may not be effective when applied at earlier stages.

7.2.5 Conclusions

Observations on sex ratio, fruit set and nut retention revealed that none of the growth regulators applied at different concentrations are capable of enhancing sex ratio, fruit set and nut retention in low yielding cashew varieties. Only ethrel at 150 ppm caused fruit thinning but corresponding increase in nut size or nut weight was not seen.

Table 7.2: Effect of various growth regulators on sex ratio, fruit set, fruit drop, nut retention, nut weight and nut volume of VRI-1.

Treatment	Sex ratio	Fruit set	Nut drop	Retention	Nut weight	Nut volume
T ₁ - 1ppm. 2,4-D	0.15	3.7	1.1	2.7	7.6	7.1
T ₂ – 3ppm 2,4-D	0.12	3.9	1.3	2.6	7.6	6.9
T ₃ – 5ppm 2,4-D	0.11	4.2	1.4	2.8	8.4	7.1
T ₄ – 50 ppm IAA	0.08	3.6	1.2	2.4	7.6	7.1
T ₅ – 100 ppm IAA	0.08	3.8	1.3	2.5	7.8	6.6
T ₆ – 150 ppm IAA	0.07	3.7	1.1	2.7	7.8	7.1
T ₇ – 50 ppm NAA	0.10	4.4	1.5	2.9	7.9	7.0
T ₈ – 100 ppm NAA	0.06	3.8	1.3	2.5	7.6	7.0
T ₉ – 150 ppm NAA	0.09	3.8	1.3	2.5	7.0	6.5
T ₁₀ – 1% Urea	0.09	3.7	1.3	2.5	7.9	7.2
T ₁₁ – 2% Urea	0.10	4.2	1.4	2.8	7.5	6.8
T ₁₂ – 3% Urea	0.08	3.9	1.5	2.4	7.5	6.9
T ₁₃ Water spray	0.10	4.5	1.8	2.7	7.6	6.9
T ₁₄ – No spray	0.17	3.3	1.1	2.4	7.4	6.9
Mean	0.10	3.9	1.3	2.3	7.7	6.9
CD (p = 0.05)	NS	NS	NS	NS	NS	NS

Table 7.3: Effect of chemical fruit thinners on fruit drop, nut size, volume and retention in Kanaka.

Treatment	Nut drop	Retention	Nut weight	Nut volume
T ₁ - 50 ppm. Ethrel	1.6	4.8	6.7	5.9
T ₂ – 100 ppm. ethrel	1.0	6.4	7.3	6.2
T ₃ – 150 ppm. ethrel	1.2	5.8	7.3	6.2
T ₄ – 100 ppm NAA	1.6	4.8	6.0	4.8
T ₅ – 200 ppm NAA	0.6	5.6	5.6	4.6
T ₆ – 200 ppm NAA	0.6	6.6	5.1	4.5
T ₇ – 100 ppm GA ₃	2.2	7.8	5.8	4.7
T ₈ – 200 ppm GA ₃	1.2	7.4	5.5	4.7
T ₉ – 300 ppm GA ₃	0.8	6.6	5.6	4.9
T ₁₀ – 1% KNO ₃	1.6	7.2	5.5	4.9
T ₁₁ – 2% KNO ₃	1.4	5.8	5.7	5.0
T ₁₂ – 3% KNO ₃	0.4	6.8	6.0	4.8
T ₁₃ Water spray	0.8	6.4	5.5	4.8
T ₁₄ – No spray	1.2	6.8	5.7	4.9
Mean	1.2	6.6	6.8	6.04
CD (p = 0.05)	NS	NS	NS	NS

7.3: Integrated Pest Management of Cashew Stem and Root Borers (CSRB)

Project Leader	:	Dr. T.N. Raviprasad
Project Associate	:	Dr. P. Shivarama Bhat, Dr. D. Sundararaju Dr. K.V. Nagaraja
Project Number	:	3.4
Project Duration	:	5 years (1998-2003)

7.3.1 Introduction:

Pest incidence leading to yield losses and reduction of tree population is one of the main constraints in enhancing productivity of cashew in India. Cashew farmers and development agencies have less awareness about the pest damage and initial damage symptoms. As prophylactic treatment was found to be ineffective due to degradation of pesticides, the methodology involving extraction of CSRB at different stages from infested trees and providing post extraction prophylaxis (PEP) was evaluated. In order to effectively manage this pest, detailed information on the period of initiation of pest attack and egg laying period were essential. Laboratory culturing of test insects to obtain uniform aged beetles for evaluatory trials by adopting of semi-synthetic diet (SSD) was to be attempted. The pest was found to be attacking the already infested trees which might be due to certain volatiles inducing egg laying by female beetles of CSRB.

7.3.2 Objectives

- i) To evaluate various insecticidal treatments for their efficacy in checking reinfestation by CSRB as post treatment prophylaxis (PTP).
- ii) To standardize age estimation technique for field collected grubs and to assess activities of indigenous natural enemies.
- iii) To standardise semi-synthetic diet for rearing of CSRB under lab conditions.

- iv) Trials on presence of pheromones and response to host plant kairomones.

7.3.3 Materials and methods

7.3.3.1 Post treatment prophylaxis trials

Under these trials, carbaryl (1.0%), chlorpyrifos (0.2%), lindane (0.2%), monocrotophos (0.2%) were evaluated as swabbing and drenching after removal of CSRB grubs by mechanical means. The number of trees without fresh incidence / residual symptoms will be recorded to estimate efficacy of the test insecticide.

7.3.3.2 Age estimation technique

The width of prothoracic shield (PTS) of laboratory cultured CSRB grubs was measured for at 15 days interval. Based on the results the number of instars as well as the possible age of the grub was standardized.

7.3.3.3 Survey for indigenous natural enemies

The CSRB at different stages were collected from infested trees and reared under the conditions. Emergence of parasitoid or development of disease was recorded and the natural enemy was further multiplied.

7.3.3.4 Semi-synthetic diet (SSD)

As the insect is an excessive and voracious feeder, the natural host feed may not be procurable for large scale mass culturing of the pest. Hence, the use of host bark as a phagostimulant and grain flours as bulking flours along with suitable mineral and vitamin additives was evaluated. The duration of feed change, quantity of feed required and the development of the grubs on SSD in comparison to natural bark were studied.

7.3.3.5 Trials on sex kairomones and pheromones

The cashew trees beheaded for purpose of top working were found to succumb to severe infestation by CSRB. This may be due to volatiles secreted from cut branches which needs to be extracted and analysed for composition. The frass material in earlier trials showed that it could elicit higher egg laying. Hence, the components in frass need to be characterized by GCMS.

7.3.4 Results

7.3.4.1 Post treatment prophylaxis trials

During the year 1998-99 it was observed that the trees free from reinfestation was 75.0 per cent in case of lindane (0.2%) followed by 70.0 per cent in case of monocrotophos (0.2%). Infestation persisted in some treated trees and fresh incidence was not observed during the months of June to September (Table 7.4).

During 1999-2000, the treatments with lindane (0.2%), monocrotophos (0.2%), chlorpyriphos (0.2%) as well as carbaryl (1.0%) could result in 100.0 per cent recovery when trees in initial stage of attack were treated by drenching and swabbing. The recovery levels ranged between 8.7 to 26.3 when trees in moderate stage of infestation and there was no recovery when trees at severe stages of infestation were treated (Table 7.5). During 2001-2002, chlorpyriphos (0.2%) gave the maximum mean recovery of 82.52 per cent and treated trees were free from reinfestation for 45 days (Table 7.6).

7.3.4.2 Standardization of age estimation technique

The plant protection activities need to be timed accurately based on initiation of pest incidence. Hence, the possible period of egg laying needs to be clearly identified. The prothoracic shield (PTS) width which is chitinised, was measured at 15 days intervals. The body length did not have any relation to age as it varied depending on food content in the gut. The tabulation of standardized PTS width for different age groups is mentioned in Table 7.7.

7.3.4.3 Semi-synthetic diet (SSD)

The nascent grubs of CSRB were reared on cashew bark of 2m x 2m for 24 days and later released on SSD pieces. The composition of SSD was modified to include host bark fibre as phagostimulant and griseofulvin as antifungal antibiotic agent. The weight gain of CSRB grubs was recorded at 30 days intervals and indicated 22-33 percent increase over those reared on host bark. Similarly percent survival was higher on SSD in comparison with host bark. The composition of SSD the comparative grub development on host bark and SSD are presented in Table 7.8 and 7.9 respectively.

7.3.4 Survey for indigenous natural enemies

CSRB at different stages were collected from plantations of KCDC. These were reared under laboratory conditions to symptoms of diseases or parasitism. The entomopathogenic fungus, *Metarhizium anisopliae* was the only natural enemy encountered on grubs at older and pupal stages. This was evaluated in field trials by mixing spawn with ripe cashew apples. Mixing of spawn with soil led to mortality of 100.0 per cent on 90 DAT indicating spore viability and virulence.

From the trials on survivability of spores in soil and on cashew apple, it could be inferred that spawn was virulent and could induce mycosis upto 120 days (33.33 per cent). Jowar grains as culture media resulted in higher spore production compared to cashew apples. Under field conditions, *M. anisopliae* spawn could not check reinfestation by CSRB and could not induce mycosis of grubs in infested cashew tree which confirmed its inefficiency in pest management

7.3.4.5 Trials on presence of kairomones

Extracts and volatile concentrates of fresh bark, infested bark and frass in n-hexane were evaluated using EAG. Extracts of frass could induce highest

response in mated female beetles (Table 7.10). The composition of the test material inducing highest response was analysed by GCMS by Rembold's method. The constituents were mainly composed of decanes, phenols and small chain acids (Table 7.11).

The components which showed more response compared to geraniol (100.0%) were methyl myristate (140.2%), cyclo hexanol (135.1%), phthalic acid (108.1%) and methyl cyclopentane (107.9%) (Table 7.12).

7.3.5 Conclusions

- Trials on PTP have clearly indicated that only the trees at initial stages of infestation (with <25.0 per cent bark circumference damaged) could recover fully on treatment with insecticide chlorpyrifos 0.2%, which can be recommended as plant protection technique to prevent further spread of the pest.
- In order to schedule the plant protection activities, the period of initiation of pest incidence is essential. Using PTS width as an indicator of age helps in obtaining the period of pest incidence. As the pest is known to be a voracious feeder, providing of natural host bark for rearing is not feasible, hence the SSD which has been proved to enhance grub weight and survival will be of use in getting sufficient number of uniform aged adults. EAG trials have indicated strong response to the extracts and concentrates of frass and gum.

7.3.6 Publications

Raviprasad, T.N. and **Bhat, P.S.** 1998. Laboratory rearing techniques for cashew stem and root borer, *Plocaederus ferrugineus* Linn. (Coleoptera : Cerambycidae). PLACROSYM-XIII Coimbatore, 16-18 Dec. 1998. **In:** Recent Advances in Plantation Crops (2000) pp 346-351.

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 ferrugineus* (Coleoptera : Cerambycidae). PLACROSYM-XIV, Hyderabad, 12-15 Dec. 2000. **In:** Plantation Crops Research and Development in the New Millennium (2002) 147-149.

Table 7.4: Efficacy of post treatment prophylaxis on checking reinfestation.

Insecticidal suspension	Mean % trees without re-infestation	Cost/tree/round (Rs.)	
		Swabbing	Drenching
Chlorpyriphos 0.2%	55	3.62	7.20
Monocrotophos 0.2%	70	2.28	4.56
Carbaryl 1.0%	65	6.40	12.80
Lindane 0.2%	75	1.50	3.00
CD at 5%	NS	--	--

Table 7.5: Recovery of trees in different pesticidal treatments as post-treatment prophylaxis.

Treatment	No. of trees treated	Recovery in different stages of attack		
		Initial	Moderate	Severe
Lindane 0.2%	88	100.0 (47/47)	14.3 (3/21)	0.0 (0/20)
Chlorpyriphos 0.2%	88	100.0 (47/47)	8.7 (2/23)	0.0 (0/18)
Monocrotophos 0.2%	88	100.0 (55/55)	26.3 (5/19)	0.0 (0/14)
Carbaryl 1.0%	90	100.0 (25/25)	13.3 (2.15)	0.0 (0/23)

Table 7.6: Recovery levels under different insecticidal treatments as PTP.

PTP Treatment imposed	No. of trees	Mean recovery (%)	Period free from reinfestation (in days)
Lindane	38	77.36	30
Monocrotophos	38	60.64	30
Chlorpyriphos	38	82.52	45
Carbaryl	38	74.56	15
Test of signifinance	-	NS	-

Table 7.7: Morphometrics of CSRB grubs (*P. ferrugineus*)

Age of CSRB grubs (in days)	Prothoracic shield width		Body length	
	Range	Mean	Range	Mean
Nascent	0.30 – 0.30	0.25	0.4 - 0.8	0.6
15	0.30 - 0.50	0.40	1.0 - 2.5	2.0
30	0.35 - 0.50	0.0	1.0 - 2.5	2.0
45	0.35 - 0.50	0.40	1.0 - 3.0	2.5
60	0.55 - 0.70	0.60	3.0 - 5.0	4.5
75	0.55 – 0.70	0.60	3.0 - 5.0	4.5
90	0.55 - 0.70	0.60	3.0 - 5.0	4.5
105	0.75 - 0.90	0.80	5.0 - 7.0	5.5
120	0.75 - 0.90	0.80	5.0 - 7.0	.5
135	0.95 - 0.10	1.00	7.5 - 8.5	8.0
150	0.95 - 1.10	1.00	7.5 - 9.0	8.0
165	1.20 – 1.40	1.25	8.5 - 10.0	9.5
180	1.20 - 1.40	1.25	8.5 - 11.0	9.5

Table 7.8: Composition of semi-synthetic diet (SSD).

Ingredient	Quantity
Host bark – Phagostimulant	100 g
Bengal gram powder – Protein source and diet base	105 g
Surcose	75 g
Agar-agar – Carbohydrate source	22 g
Yeast – Catalyst	15 g
Ascorbic acid – Vitamin C	6 g
Multivitamin drops – Other vitamin source	6 ml
Methyl para benzoate – Antifungal agent	3 g
Formalin – Antiviral agent	Few drops
Sorbic acid – Preservative	1.5 g
Griseofulvin – Antibacterial agent	1.5 g
Distilled water	665 ml

Table 7.9: Development of grubs of *P. ferrugineus* on semi-synthetic diet (SSD) and host bark.

Age of grubs	Weight gain		% difference 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

Table 7.10: EAG response of mated female CSRB beetles.

Extracts / Volatiles	Weight of plant material	EAG response
Extracts		
Healthy bark	15	0.381c
	30	0.814 b
	45	0.311 bc
Fresh frass	15	0.182 a
	30	0.260 ab
	45	0.327 c
Volatiles		
Healthy bark	15	0.237 ab
	30	0.211 ab
	45	0.277 ab
Fresh frass	15	0.269 ab
	30	0.216 ab
	45	0.289 bc
CD at 5%		0.106

Table 7.11: The compounds identified by Rembold 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, deconic acid, tetradecane, pentadecane, dimethyl 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, dimethyl ethyl phenol and hexadecane.
Hexane extract of cashew apple aroma distillate	Cyclohexanol, dichlorobenzene, limonene, undecane, naphthalene, dodecane, benzotriazone, decanoic acid, hexadecane, tetradecane, heptacosane, heptadecane.

Table 7.12: EAG responses by mated female beetles of CSRB to various host plant components obtained from GCMS.

Name of component	% response
Methyl myristate	140.2
Cyclohexanol	130.1
Phthalic acid	108.1
Methyl cyclopentane	107.9
Geraniol (use for comparison)	100.0
Naphthalene	99.6
Cyclohexane	83.0
Methylester of deconic acid	81.2
1-2, dichlorobenzene	80.9
Methyl arachidate	49.6
Cyclopentane	45.8
n-hexadecane	16.4

7.4: Integrated Pest Management (IPM) of Tea Mosquito Bug (TMB)

Project Leader	:	Dr. D. Sundararaju
Project Associates	:	Dr. T.N. Raviprasad Dr. P.S. Bhat
Project Number	:	3.5
Project Duration	:	5 years (1998-2003)

7.4.1 Introduction

Tea mosquito bug causes moderate to severe yield loss during different years. In order to combat the pest, which persists all through the cropping season, the need for a pesticide with longer activity and lesser pesticidal residues was felt. Also stress was laid on use of bio-products to eliminate residue problems. Among the host specific natural enemies, egg endoparasitoids (*Telenomus* sp. *Laricis* group and *Chaetostricha* sp.) were quite promising. Since, These parasitoids are not amenable for mass culturing through conventional rearing methods, suitable conservation and enhancement techniques need to be evolved under field conditions for enhancing the natural biological control of TMB..

6.4.2 Objective

To develop different IPM methods (chemical and biological control) for management of TMB.

7.4.3 Material and Methods

7.4.3.1 Evaluation of new insecticides and bio-products

Inorder to find out the ovicidal action in eggs and residual action against first instar nymphs, insecticides were individually sprayed on cashew seedlings having TMB eggs. Simultaneously, healthy undamaged cashew seedlings having tender flushes were also treated with same insecticides. Both TMB egg laden and healthy undamaged treated cashew seedlings of respective treatment were tied together in such a way that the newly hatched nymphs can migrate and feed on the tender flushes of undamaged healthy treated cashew seedlings. The

damage was scored on third day after hatching of nymphs. The extent of hatching of eggs was estimated from TMB egg laden seedlings on fifth day of hatching by dissecting the egg-laden shoots under stereoscopic dissection microscope. The experiment was replicated thrice. To determine the oviposition deterrence, two gravid TMB females were caged for 48 h in a mosquito net cage on single tender shoot in each replication on treated young trees of Kunthur-24

The population (no.) of TMB and damage grade recorded under evaluation of insecticides for residual action and number of eggs laid under oviposition deterrence were analysed in a factorial completely randomized block design (CRBD) after $\sqrt{x+0.5}$ transformations. The hatching percentage of eggs and damage grade (after transformation) of first instar nymphs were analysed in CRBD. Mean values were compared at least significance difference test (LSDT).

7.4.3.2 Enhancement of natural biological control

The study was conducted for three years from October 1997 to September 2000 at NRCC Experimental Station, Shanthigodu. The gravid females of *H. antonii* (6 gravid females/week and 1-2 females/cage) were periodically caged for oviposition on shoots of existing phenological stage (as tender or matured shoot) of the cashew tree during respective standard week. Every time gravid females maintained in each cage were allowed for oviposition for 48 h on each respective cashew shoot and afterwards the cages will be shifted to other available shoots in the respective week. Thus the egg-laden shoots were regularly exposed for natural parasitism by egg parasitoids as host enrichment technique (HET). After 30 days of oviposition, the individual egg-laden shoot was severed and all the external portion of shoot and petioles and midribs of leaves were critically examined under stereoscope microscope to locate the host eggs by observing the two unequal extra chorionic process of each egg present externally. The portion of plant part containing eggs was dissected to sort out stages of egg parasitism and species composition. Finally the number of host

eggs laid in each standard week was added and percentage of egg parasitism was worked out. Based on total number of eggs and the number of parasitised eggs having adult parasitoid emergence hole, the percentage of emergence was calculated. The egg parasitism by different species was partitioned based on species composition. The relative emergence of different species of egg parasitoid was calculated as per following formula.

Relative emergence of species “x” =

$$\frac{\text{Percent parasitism as emerged on 30}^{\text{th}} \text{ day of exposure of host eggs by species “x”}}{\text{Percentage of total egg parasitism of same species “x”}} \times 100$$

The extent of egg parasitism and relative emergence of adult parasitoids recorded during each week were subjected to correlation analysis with weekly mean of weather parameters in order to find out the relationship between weather parameters and enhancement of the activities of the egg parasitoids.

7.4.3.3 Seasonal incidence of TMB

Twelve trees of Goa 11/6 were chosen by stratified random sampling and in each tree, 52 leader shoots were tagged at random and TMB population was recorded regularly in each week starting from October 1999 to last week of May 2000 on those tagged shoots. From the same marked trees, the TMB population count was recorded in subsequent three seasons (October to May of 2000-01, 2002-02 and 2002-03 after necessary tagging of new leader shoots).

7.4.3.4 Evaluation of new insecticide and bio-products

Population growth of TMB was estimated by obtaining the difference between average TMB population recorded during particular week and that recorded during the preceding week. This growth value was used to work out correlations with particular week weather parameters. Further, correlation was worked out between average TMB population recorded

during different weeks and that of weather parameters. These weather parameters were for the first, second and a third preceding week to respective current week in which actual TMB population was counted. This analysis was made to determine required time lag or lead-time to suggest/undertake appropriate management strategy for preventing or containing the outbreak of this pest.

7.4.4 Results

7.4.4.1 Evaluation of new insecticides and bio-products

All insecticides tested had ovicidal effect, but with maximum residual action against first instar nymphs except in treatments of endosulfan, Dillapiole and quinalphos (Table 7.13 & 7.14). However, *L.* cyhalothrin followed by carbaryl and monocrotophos exhibited highest residual action for seven days than other insecticides against late instar nymphs and adults of TMB and also showed least oviposition on treated shoots (Table 7.15 and 7.16). Even though, the combination product profenophos + cypermethrin also exhibited highest residual action against nymphs and adults, its residual effect on oviposition was on par with untreated control (Table 7.14).

In the earlier trials, λ -cyhalothrin (0.003%), cartap (0.075%) were found to be equally effective with recommended standard insecticides. This was again compared in a larger plot trial (72 – 102 trees/plot) along with spray oil (1ml/l) in an exploded block design. Three rounds of sprays were given in the first fortnight of December 2002, second fortnight of January and February 2003. The damage (0-4 scale) was assessed before each spray and one month after third spray. The total predatory population (spider, ants, mirid, reduviid and geocorid bugs, preying mantids and chrysopids) exiting on 52 panicles per tree was also recorded one month after third spray. The results were compared through paired 't' test. Carbaryl and λ -cyhalothrin treatments were found to be superior and cartap was found to be ineffective, as it has scored TMB damage on par with untreated control. The data on

predatory fauna indicated that the total predatory fauna was highest in the cartap treated plot. As mealy bug infestation was noticed only in this plot, it might have enhanced total predatory fauna. But λ -cyhalothrin treatment recorded least number of spiders (0.05 spider/panicle) than other treatments (0.18 – 0.40 spiders/panicle) but recorded highest population of predatory mirid bug (0.48/panicle) than other treatments (0.12 - 0.29/panicle). Previous studies have revealed that spider population has not reduced the incidence of tea mosquito bug in the unsprayed plots and its drastic reduction due to λ -cyhalothrin treatment may not cause any resurgence of TMB in case λ -cyhalothrin is treated on regular basis. Therefore, λ -cyhalothrin (0.003%) can be recommended for management of TMB as an alternative insecticide and it is also cheaper than carbaryl (Table 7.17 and 7.19).

7.4.4.2 Enhancement of natural biological control

The data on extent of egg parasitism of TMB collected during last three years (1997-2000) under host enrichment technique (HET) were correlated with weather parameters (Tables 7.20 and 7.21). During vulnerable period of cashew crop (November-February), the egg parasitism has shown independent relationship whereas, in the remaining period, positive density dependent relation was observed. The percentage egg parasitism was negatively influenced by maximum temperature, evening soil temperature, evaporation and wind velocity. The percentage of relative emergence of dominant species of egg parasitoids (*Telenomus* sp.) was negatively influenced by maximum temperature, bright sunshine hours, evening soil temperature and evaporation and positively influenced by relative humidity, rainfall and rainy days, whereas, for the minor species of parasitoids (*Chaetostricha* sp), the minimum temperature influences positively. The prediction equations were worked out based on stepwise regression. But, the R^2 value was in the range of 0.086 to 0.306 indicating low level of accountability of weather factors. However, minimum temperature, relative humidity and rainfall have shown positive relationship on percentage of egg

parasitism and relative emergence of egg parasitoids during vulnerable period of the crop (November-February). These factors, may promote enhanced activities of egg parasitoids that may reduce the chance of pest outbreak during vulnerable period of the crop.

7.4.4.3 Seasonal incidence of TMB

The population of TMB were recorded at weekly intervals from October to May of each cropping season from 1999 to 2003. From the population of TMB recorded on 12 trees, its growth rate was worked out. Correlations between population, growth rate and weather parameters were worked out (Table 7.22). Population growth of TMB was not influenced by any of these weather parameters. This indicated that population growth is independent of weather factors, but it is probably related to fecundity of females in generation t , or to survival of their progeny in generation $t + 1$, or to both processes. When average population of TMB was correlated with weather parameters of first, second and third preceding week, it was found that minimum temperature was significantly negatively correlated. But under multiple regression analysis, involvement of all weather parameters was found to be insignificant. Therefore, the population was analysed again after log transformation. In that analysis, most of the weather factors were significantly correlated. But under multiple regression analysis, the R^2 value was 0.608 (Table 7.23). When all significant parameters alone were used, it was 0.502. Again it was repeated with significant weather parameters that had scored with correlation 'r' value more than 0.5 and R^2 value was 0.411. It also indicate the low level of accountability in the prediction equation. However it gives an indication that monitoring minimum temperature (Table 7.24) alone may be a useful tool in predicting the possible out break of TMB in cashew plantation.

7.4.5 Conclusions

Method for testing the ovicidal and residual action of insecticides was refined. Carbaryl (0.1%), monocrotophos (0.05%) and lambda cyhalothrin

(0.003-0.005%) had shown maximum residual action out of nine insecticides tested and not affected insect pollination. As such, under outbreak situation, the above insecticides on timely application could only rescue the crop from the ravages of this pest. Further, λ - cyhalothrin(0.003%) had shown highest cost benefit ratio of 4.5 in the large plot trial. All plant products especially neem based commercial formulations, Dillapiole and GB(garlic based formulation) were found to be ineffective against this pest. Minimum temperature exerted significant positive influence. Population growth of TMB was not influenced by any of the weather parameters. However, monitoring minimum temperature alone may be a useful tool in predicting the possible outbreak of TMB in cashew plantation.

7.4.6 Publications

7.4.6.1 Research Papers

Sundararaju, D. 2002. Description of endoparasitism in nymphs and adults of *Helopeltis* spp. infesting cashew. *J. Plantn. Crops* 30: 66-68.

Sundararaju, D.2002. Life table studies of *Helopeltis antonii* Sign. (Heteroptera : Miridae) under field condition. *Insect Environment* 8: 55-57.

Sundararaju, D., Raviprasad, T.N. and Bhat, P.S. 2002. New refuge host plant for *Helopeltis* spp. *Insect Environment* 8: 137-138.

Sundararaju, D. 2003. Record and cumulative effect of recommended insecticidal spray schedule on predatory fauna of cashew pests *The Cashew* 17(1) :30-34.

Sundararaju, D. 2002. Influence of spiders and insect predators on incidence of tea mosquito bug in cashew (Accepted for publication in *The Cashew*).

Sundararaju, D. 2002. Behaviour of egg parasitoids on *Helopeltis antonii* Sign. (Heteroptera : Miridae) in relation to weather parameters (Accepted for Publication in *Journal of Pest Management in Horticultural Ecosystem*).

Sundararaju, D.2003. Evaluation of certain insecticides against tea mosquito bug on cashew (Communicated to *Pestology*).

Sundararaju, D.2003.Influence of weather factors on oviposition and egg parasitism of tea mosquito bug in the tender flush stage of cashew. (Communicated to *Journal of Plantation Crops*).

7.4.6.2 Book Chapters

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

Bhat, P.S., Sundararaju, D. and Raviprasad, T.N. 2002. Integrated management of insects pests and diseases in cashew. *In: Indian Cashew Industry* (Eds. Singh, H.P.,Balasubramanian, P.P. and Hubballi,V.N.). Directorate of Cashew and Cocoa Development, Kochi.pp-111-117.

7.4.6.3 Popular Articles

Sundararaju, D. 2002. Pests and disease management of cashew in India. *The Cashew* 16 (4): 32-38.

Table 7.13: Residual effect of new insecticides on survival and damage of TMB in the first trial conducted during 1998-99 season.

Treatments	No. surviving after 24 h when caged on				Damage grade during 48 h after caging on			
	same day	3 rd day	7 th day after spraying	Mean	Same day	3 rd day	7 th day after spraying	Mean
Dillapiolle 1.0%*	4.0 ^{bA}	3.7 ^{bA}	5.0 ^{cB}	4.2 ^c	3.0 ^{dA}	3.7 ^{cB}	3.0 ^{dA}	3.2 ^b
Endosulfan 0.05%	0.0 ^{aA}	4.0 ^{bB}	5.0 ^{cB}	3.0 ^b	3.0 ^{dA}	3.7 ^{cB}	3.0 ^{dA}	3.2 ^b
Monocrotophos 0.05%	0.0 ^{aA}	0.0 ^{aA}	0.0 ^{aA}	0.0 ^a	1.0 ^{bA}	1.0 ^{bA}	1.3 ^{bA}	1.1 ^a
Carbaryl 0.1%	0.0 ^{aA}	0.0 ^{aA}	0.0 ^{aA}	0.0 ^a	0.7 ^{bA}	1.0 ^{bA}	0.7 ^{aA}	0.8 ^a
Profenophos 0.05%	0.0 ^{aA}	4.3 ^{cB}	4.3 ^{cB}	2.9 ^b	2.7 ^{dA}	3.0 ^{cA}	3.0 ^{dA}	2.9 ^b
Profenophos 0.05% + Cypermethrin 0.005%	0.0 ^{aA}	0.0 ^{aA}	1.3 ^{bB}	0.4 ^a	0.0 ^{aA}	0.0 ^{aA}	2.0 ^{cB}	0.7 ^a
Quinalphos A.F. 0.05%	0.0 ^{aA}	3.7 ^{bB}	4.7 ^{cC}	2.8 ^b	2.0 ^{cA}	3.0 ^{cB}	3.0 ^{dB}	2.7 ^b
Untreated control	6.0 ^{cA}	6.0 ^{dA}	6.0 ^{dA}	6.0 ^c	3.0 ^{dA}	3.3 ^{cA}	3.0 ^{dA}	3.1 ^b

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

*--- Plant product.

Table 7.14: Residual effect of new insecticides on oviposition, hatching of eggs and damage by first instar nymphs of TMB in the first trial conducted during 1998-99 season.

Treatments	No. of eggs/female in 48 h when caged on [@]				Hatching of eggs (%) [*]	Damage grade by 1 st instar nymphs
	same day	3 rd day	7 th day after spraying	Mean		
Dillapiolle 1.0% [#]	24.3	19.0	27.0	23.4 ^c	100.0	4.0 ^b
Endosulfan 0.05%	11.0	15.0	15.3	13.8 ^b	100.0	4.0 ^b
Monocrotophos 0.05%	3.0	0.7	6.0	3.2 ^a	100.0	0.3 ^a
Carbaryl 0.1%	1.3	0.0	0.7	0.7 ^b	100.0	0.0 ^a
Profenophos 0.05%	2.3	15.7	19.7	12.6 ^{ab}	100.0	0.0 ^a
Profenophos 0.05% + Cypermethrin 0.005%	0.7	1.3	20.3	7.4 ^c	100.0	0.0 ^a
Quinalphos A.F. 0.05%	13.7	22.3	30.3	22.1 ^c	100.0	4.0 ^b
Untreated control	9.0	13.7	31.0	14.6 ^{bc}	100.0	4.0 ^b

[#] Plant product.

Mean followed by common small letter in each column is not significantly different at 5% LSDT;

[@]- Treatments x periods interaction is not significant. * Non-significant at LSDT.

Table 7.15: Residual effect of new insecticides on survival and damage of TMB in the second trial conducted during 1999-00 season.

Treatments	No. surviving after 24 h when caged on				Damage grade during 48 h after caging on*			
	same day	3 rd day	7 th day after spraying	Mean	Same day	3 rd day	7 th day after spraying	Mean
Monocrotophos 0.05 %	0.0 ^{aA}	0.0 ^{aA}	0.0 ^{aA}	0.0 ^a	0.3	1.3	2.0	1.2 ^b
Carbaryl 0.1 %	0.0 ^{aA}	0.0 ^{aA}	0.0 ^{aA}	0.0 ^a	0.7	0.7	3.0	1.4 ^{bc}
L.cyhalothrin 0.005 %	0.0 ^{aA}	0.0 ^{aA}	0.0 ^{aA}	0.0 ^a	0.0	0.3	1.3	0.6 ^a
Acephthate 0.075 %	0.0 ^{aA}	0.0 ^{aA}	3.7 ^{cB}	1.2 ^c	0.3	2.3	3.3	2.0 ^{cd}
Carbosulfan 0.05 %	0.0 ^{aA}	0.0 ^{aA}	1.3 ^{bB}	0.4 ^b	1.7	1.7	2.7	2.0 ^d
Control	6.0 ^{bA}	6.0 ^{aA}	6.0 ^{dA}	6.0 ^d	3.3	3.7	4.0	3.7 ^e

Mean followed by common small letter in each column or common big letter in each row is not significantly different at 5% LSDT. * Treatments x periods interaction is not significant.

Table 7.16: Residual effect of new insecticides on oviposition, hatching of eggs and damage by first instar nymphs of TMB in the second trial conducted during 1999-00 season.

Treatments	No. of eggs/female in 48 h when caged on				Hatching of eggs (%)*	Damage grade by Ist instar nymphs
	same day	3 rd day	7 th day after spraying	Mean		
Monocrotophos 0.05 %	4.3 ^{cB}	1.0 ^{aA}	2.8 ^{abAB}	2.7 ^{ab}	98.4	0.0 ^a
Carbaryl 0.1 %	3.0 ^{bA}	1.8 ^{aA}	3.8 ^{abA}	2.9 ^{bc}	100.0	0.0 ^a
L.cyhalothrin 0.005 %	0.0 ^{aA}	1.8 ^{aA}	1.5 ^{aA}	1.1 ^a	100.0	0.0 ^a
Acephthate 0.075 %	7.3 ^{cB}	0.8 ^{aA}	10.7 ^{cB}	6.3 ^a	97.8	0.0 ^a
Carbosulfan 0.05 %	3.0 ^{bA}	1.5 ^{aA}	11.8 ^{cdB}	5.4 ^{bc}	96.5	0.0 ^a
Control	22.7 ^{dA}	25.0 ^{bA}	19.3 ^{dA}	22.3 ^d	100.0	4.0 ^b

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

*- - Non significant at LSDT.

Table 7.17: Evaluation of promising insecticides in large plot trial.

Treatments	TMB damage (0-4 scale) on 30 DAT	Predators (No./panicle)			Cost of chemical per tree (Rs.)*	
		Spider	Mirid bug	Total	For single spray	For three sprays
Carbaryl 0.1% + spray oil	0.19 aA	0.18 aA	0.14 aA	0.39 aA	4.56	14.00
λ-cyhalothrin 0.003% + spray oil	0.22 aA	0.05 bB	0.48 bB	0.64 aB	1.91	6.00
Cartap – 0.075% + spray oil	3.58b B	0.40 bB	0.29 aA	0.79 bB	9.30	28.00
Untreated control	3.58 b	0.23 a	0.12a	0.47 a	-	-

* 5 litre spray fluid / tree. DAT- Days after third spray.

Values in a column followed by small letter indicates the comparisons of untreated control versus respective chemical treatment and by capital letter indicates standard treatment (carbaryl) versus respective chemical treatment

Values in a column followed by common letter of either untreated control or carbaryl are not significant by paired 't' test at 5% level.

Table 7.18: Evaluation of insecticides against TMB in large plot trial – economic analysis.

Treatment	Yield kg/tree		Yield loss against carbaryl (kg/tree) ^a	Yield contribution due to insecticide (kg/tree) ^b	Gross profit (Rs./tree) ^c	Cost of insecticide application (Rs./tree) ^d	Net gain (Rs./tree) ^e	Grain from insecticide ^f	Benefit cost ratio
	Sample trees	Whole plot							
Carbaryl	3.98	2.88	0.0	1.71	101	22	79	38	2.73
Cyhalothrin	3.94	2.97	0.0	1.80	104	14	90	49	4.50
Cartap	2.12	2.27	0.61	1.10	79	36	43	2	1.06
Control	1.23	1.17	1.71	0.0	41	0	41	0	

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

b = Yield of the insecticidal treatment – yield of control

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

d = Cost of insecticides (Table 5) + cost of application

e = Gross profit – Cost of insecticide application

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

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

Table 7.19: Evaluation of Karate (λ -cyhalothrin 0.003% in a large plot.

Details	Results	
	Mean \pm S.E	Range
TMB Damage (0-4 scale):		
i) Pre treatment	1.78 \pm 0.38	0.03 – 3.58
ii) Post treatment	0.23 \pm 0.07	0.01 – 0.88
Natural enemies fauna:		
i) Total predatory fauna (no./panicle)	1.08 \pm 0.24	0.29 – 2.75
a) Spider (no./panicle)	0.04 \pm 0.02	0.0 – 0.13
b) Mirid bug (no./panicle)	0.48 \pm 0.07	0.21 – 0.85
c) Geocorid bug (no./panicle)	0.08 \pm 0.03	0.0 – 0.38
d) Ants (no./panicle)	0.45 \pm 0.16	0.03 – 1.63
ii) Egg parasitism of TMB by HET (%)	63.75 \pm 4.61 (62.50)	51.79 – 74.29
Insect pollination:		
i) Hermaphrodite flowers with pollen deposit (%)	53.13	-
ii) No. of pollen grains/stigma	2.53 \pm 0.39	1 – 6

Figures in brackets indicate natural egg parasitism from field collected TMB eggs.

HET = Host enrichment technique

SE = Standard error

Table 7.20: Relationship of weather factors on percent egg parasitism and percent relative emergence of adult parasitoid under HET.

Weather factors	Percent egg parasitism		Percent relative emergence of adult parasitoids on 30 DAE			
			<i>Telenomus sp.</i>		<i>Chaetostricha sp.</i>	
	A	B	A	B	A	B
Maximum temperature °C	-0.177*	-0.031NS	-0.204**	0.041NS	-0.162NS	-0.193NS
Minimum temperature °C	-0.031NS	0.398*	0.129 NS	0.319NS	0.085NS	0.544**
Relative humidity (%) – Morning	0.113NS	-0.157NS	0.232**	0.239NS	0.013NS	-0.088NS
Relative humidity (%) – Evening	0.140NS	0.231NS	0.294**	0.380*	0.144NS	0.254NS
Rainfall (mm)	-0.024NS	0.128NS	0.173*	0.407*	-0.175NS	0.344NS
Rainy days (No.)	0.057NA	0.181NS	0.183*	0.247NS	0.032NS	0.221NS
Wind speed (Km/h)	-0.269**	0.091NS	-0.086NS	-0.166NS	-0.235*	-0.001NS
Bright sunshine (h)	-0.082NS	-0.277NS	-0.189*	-0.021NS	-0.009NS	-0.181NS
Evening soil temperature °C	-0.214*	-0.273NS	-0.197*	0.069NS	-0.198*	-0.235NS
Evaporation (mm)	-0.311**	-0.297NS	-0.235**	-0.308NS	-2.048*	-0.428*

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

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

DAE Days after exposure of host eggs

NS Non significant

* Significant at P=0.05

** Significant at P=0.01

Table 7.21: Details of prediction model worked out through stepwise regression linear model.

Dependent variables (y)	Prediction equation*	R ² value
Percent egg parasitism during whole year	109.241-9.749X ₁₀ -0.0785X ₅	0.201
Percent egg parasitism during vulnerable period	57.218+5.663X ₂ -2.498X ₉	0.253
Percent relative emergence of <i>Telenomus</i> adult on 30DAE during whole year	-0.173+0.318X ₄	0.086
Percent relative emergence of <i>Telenomus</i> adult on 30DAE during vulnerable period	16.265+0.245X ₅	0.166
Percent relative emergence of <i>Chaetostricha</i> adult on 30DAE during whole year	57.004-12.075X ₁₀ -0.161X ₅ +2.792X ₂	0.274
Percent relative emergence of <i>Chaetostricha</i> adult on 30DAE during vulnerable period	-69.647+6.718X ₂	0.307

* Details of independent variables listed under weather factors in Table 9.

DAE Days after exposure of host eggs

Table 7.22: Correlation among average TMB population its growth and weather parameters during cropping season of 1999-2003 (October – May).

Weather parameters	'r' values for			
	Average TMB population vs.			Growth of TMB population vs.
	FPW	SPW	TPW	CWP
Maximum temperature (°C)	0.04NS	-0.02 NS	-0.08 NS	0.03 NS
Minimum temperature (°C)	-0.20*	-0.29**	-0.38**	0.02 NS
Maximum – Minimum temperature	0.21*	0.25**	0.32**	0.00 NS
Relative humidity – Morning (%)	0.06 NS	0.01 NS	-0.09 NS	0.12 NS
Relative humidity – Evening (%)	-0.16 NS	-0.17 NS	-0.24**	-0.07 NS
Morning – Evening Relative humidity	0.19*	0.18*	0.24**	0.10 NS
Rainfall (mm)	-0.09 NS	-0.09 NS	-0.09 NS	-0.01 NS
Rainy days (No.)	-0.13 NS	-0.13 NS	-0.13 NS	-0.02 NS
Bright sunshine (hr)	0.12 NS	0.00 NS	0.11 NS	0.02 NS
Evaporation (mm)	-0.05 NS	-0.08 NS	-0.05 NS	0.03 NS
Evening soil temperature (°C)	0.06 NS	-0.02 NS	-0.01 NS	0.00 NS

N.S. : Non-Significant; * : Significant at 5% level; ** : Significant at 1% level

FPW : First previous week weather parameters; SPW : Second previous week weather parameters

TPW : Third previous week weather parameters; CPW : Current week weather parameters

Table 7.23: Selection of weather parameters for multiple regression analysis to predict TMB population.

Weather parameters selected for regression analysis		R ² value
Details	No.	
All weather parameters of F, S & TPW	33	0.608
Weather parameters of F, S & TPW - shown significant correlation	22	0.502
Weather parameters of F, S & TPW - shown significant correlation with 'r' value > 0.4	11	0.458
Weather parameters of F, S & TPW - shown F, S & TPW - shown significant correlation with 'r' value > 0.5 (Table 13)	4	0.411

F, S & TPW - First, second and third previous week

Prediction equation with four weather parameters for TMB population/tree (y) i.e.

$$\log (y+0.5) = 0.6090 + 0.0020 X_{13} + 0.0188 X_{21} - 0.557* X_{24} + 0.0153 X_{32}$$

Where X_{13} = Second previous week minimum temperature

X_{21} = Second previous week maximum - minimum temperature

X_{24} = Third previous week minimum temperature

X_{32} = Third previous week maximum -- minimum temperature

* Significant at 5% level

Table 7.24: Correlation among average TMB log population and second and third previous week minimum temperature and their difference with maximum temperature.

Temperature	Correlation with average TMB log population
SPW minimum temperature	0.53**
SPW maximum - minimum temperature	0.53**
TPW minimum temperature	0.61**
TPW maximum - minimum temperature	0.57**

SPW - Second previous week

TPW - Third previous week

** - Significant at 1% level

7.5: Standardization of protocol for cashew apple utilization

Project Leader	:	Mrs. S. Bhubaneswari (Till 26-6-2003)
Project Associate	:	Dr. K.V. Nagaraja Dr. M.G. Nayak
Project Number	:	4.6
Project Duration	:	3 years (2001-2004)

7.5.1 Introduction

Cashew apple is the store house of most of the nutrients. Due to seasonal availability production and highly perishable nature, the utilisation is not to an appreciable extent. Hence finding the ways and means to preserve this highly perishable fruit is of utmost importance. Attempts will be made to prolong the shelf life of the whole fruit. Besides this, development of processed products like cashew apple pulp, dehydrated powder help for the off season utilisation of fruit will be attempted. The pomace rich in fibre will be incorporated with cereals and pulses for the preparation of blends. By these methods the apples which are otherwise wasted are put to use resulting in higher returns to the farmers.

7.5.2 Objectives

- i) To standardize the conditions for the extraction of fibre from cashew apple pomace and preparation of blends.
- ii) To standardize the conditions for the preparation of dehydrated cashew apple pomace to be used for RTS preparation.
- iii) To standardize the protocol for
 - a) Preparation of storage of cashew apple pulp.
 - b) Extension of shelf life of cashew apple under different conditions.

7.5.3 Results

7.5.3.1 Preparation and composition of cashew apple pomace blends

In order to develop fibre rich blends, rice, ragi and wheat flour (60%), green gram flour (40%) and cashew apple pomace powder (0-20%) were blended and analysed for both physical and chemical properties. Bulk density of different blends varied from 0.85 to 0.89. Water absorption capacity increased with increased concentration of cashew apple pomace powder in all the blends prepared. Cashew apple pomace has higher water absorption capacity (225.8%) compared to rice (109.3%), ragi (70.5%), wheat (54.6%) and green gram (68.8%). Consistency at 1:1.5 ratio increased with increased pomace concentration (pat spread decreased) indicating that higher concentration of pomace helps in retention of water by the flour blends (Table 7.25).

Composition of different flour blends with respect to protein, carbohydrate (starch), sugars was not influenced by the addition of cashew apple pomace. Cashew apple pomace contains very low level of phytic acid, an anti nutritional factor (8.23 µg/100 mg) compared to ragi flour (15.1), green gram flour (310.99), whole wheat flour (18.04) and rice flour (19.85). Cashew apple pomace is rich in crude fibre (15.75%) compared to rice (0.03%), wheat (1.66%), ragi (3.04%) and green gram (0.28%). Crude fibre content in all the blends increased with increased concentration of cashew apple pomace powder. In vitro digestibility of protein and carbohydrate (starch) is not affected when cashew apple powder is blended upto 10% concentration. In vitro digestibility of carbohydrate in cashew apple pomace is not observed indicating that carbohydrate component in the cashew apple pomace is indigestible and adds to fibre. Thus cashew apple pomace could be blended with cereals and pulses upto 10% (Table 7.26).

7.5.3.2 Storage studies of the blends

Blends of cereals and pulses with cashew apple pomace were prepared. The following six combinations were taken for storage studies.

- Riceflour - Greengram flour (60:40),(A)
- Riceflour - Greengram flour: pomace powder(60:30:10),(B)
- Wheat flour - Greengram flour(60:40),(C)
- Wheat flour - Greengram flour: pomace powder(60:30:10),(F)
- Ragi flour - Greengram flour(60:40),(E)
- Ragi flour - Greengram flour: pomace powder(60:30:10),(F)

The blends were analysed for bulk density, water absorption capacity, crude fibre, consistency, moisture content during storage. Bulk density of stored sample over 12 month period of storage did not vary much. Water absorption capacity and consistency did not show much variation in all the samples during storage. Calcium content ranged from (75.70-125.85 μ g/mg). Calcium content was more in rice based samples. Magnesium content ranged from (1.87-4.27 μ g/mg). Ragi based sample had more magnesium content. The potassium content ranged from (5.60-35.75 μ g/mg) Rice based sample had more potassium content (Table 7.27).

The blends prepared were analysed for protein, starch, tannin, peroxide and phytic acid and invitro digestibility of protein and carbohydrates during storage at ambient temperature upto 12 months. Protein starch and tannin tend to increase during storage. Change in phytic acid during storage was not uniform. Invitro digestibility of both protein and carbohydrate was not affected during storage. Results indicated that flour blends could be stored upto 12 months at ambient temperature without quality deterioration (Table 7.28).

7.5.3.3 Osmotic dehydration studies

Osmotic dehydration of cashew apple was done at sucrose concentration ranging from 30-70% for 8 h and 16 h of soaking time with sample to solution ratio of 1:4. Water loss ranged from 21-37% in 8 h and (23-33%) in 16 h. Water loss was more for osmosed samples at 16 h. The osmosed samples were dried at 65°C in cabinet drier, up to 5% moisture content.

7.5.3.4 Preparation of cashew apple candy:

Cashew apple soft candy has been prepared with clarified cashew apple juice, sugar, and skim milk powder. To 100 ml of clarified juice, 50 g of cane sugar was added and dissolved. The solution was boiled to 1/3rd its original volume (till the thread like consistency is obtained) and at this stage, 5 g of skim milk powder was added and stirred and poured on to a greased aluminium foil in petri dish and allowed to set at room temperature. This has been organoleptically evaluated for colour, flavour, taste and texture and has been found to be acceptable.

7.5.3.5 Preparation of cashew apple pomace powder in large quantity

About 5 kg of cashew apple pomace from cashew apples collected from NRCC gene bank and different experimental plots was prepared and the material has been handed over to ICAR Research Complex for Goa, Goa for feeding trials with Japanese quails in order to develop cashew apple pomace based animal feeds.

6.5.3.6 Characterization of crude fibre for functional properties

Crude fibre from cashew apple pomace, whole cashew kernel testa, and methanol extracted testa has been extracted. Cashew apple waste with and without growing *Pleurotus* was collected from ICAR Research Complex for Goa, Goa and crude fibre has been isolated and studied. Similarly crude fibre from methanol extracted whole and CNSL expelled cashew shell and

water extracted CNSL expelled cashew shell was extracted for studies on functional properties (Tables 7.29 - 7.31).

7.5.3.7 Isolation of colour and protein

Attempts were made to extract the colour with different solvents from cashew apple skin of one of the pink coloured accessions from NCGB. Characteristic peak was not observed and there was non specific absorption. Pectin has been isolated from cashew apple pomace and the pectin thus isolated was compared with commercial sample of pectins. Cashew apple pectin had lower ash content (2.54%) compared to commercial pectin (7.46%). The equivalent weight of cashew apple pectin is 181.17 and had a methoxyl content of 6.87

Table 7.25: Physical properties of different blends containing cashew apple pomace

Flour blend	Water absorption capacity (g/g)	Consistency		
		1:1	1:15	1:2
Rice + Green Gram (60:40)	1.157	3.6	4.77	9.07
Rice + Green Gram + Pomace (60:35:5)	1.040	3.5	4.97	9.13
Rice + Green Gram + Pomace (60:30:10)	1.186	3.5	4.03	8.13
Rice + Green Gram + Pomace (60:25:15)	1.502	-	3.65	6.57
Rice + Green Gram + Pomace (60:20:20)	1.524	-	3.55	5.65
Wheat + Green Gram (60:40)	0.758	3.5	5.1	8.87
Wheat + Green Gram + Pomace (60:35:5)	0.856	3.5	4.8	8.33
Wheat + Green Gram + Pomace (60:30:10)	1.037	3.5	4.07	7.37
Wheat + Green Gram + Pomace (60:25:15)	1.284	3.43	4.03	6.85
Wheat + Green Gram + Pomace (60:20:20)	1.385	3.40	3.57	5.50
Ragi + Green Gram (60:40)	0.804	3.96	7.8	9.80
Ragi + Green Gram + PP (60:35:5)	0.857	3.76	7.43	9.63
Ragi + Green Gram + PP (60:30:10)	1.094	3.63	6.70	9.53
Ragi + Green Gram + PP (60:25:15)	1.182	3.50	5.70	9.00
Ragi + Green Gram + PP (60:20:20)	1.138	3.50	4.85	8.87

PP = Pomace Powder

Table 7.26: Composition of different blends containing cashew apple pomace.

Blends	Proportion (%)	Protein (%)	Starch (%)	Sugars (%)	Phytic acid (mg/100 mg)	Crude fibre (%)	Tannin (mg/100 mg)	In vitro digestibility	
								Protein (%)	Carbohydrate
Ragi flour	100	6.54	77.45	0.74	15.1	3.04	127.96	12.32	3.73
Green gram flour	100	40.23	51.85	5.09	310.99	0.28	34.43	35.12	3.36
Whole wheat flour	100	19.54	67.71	3.19	18.04	1.68	8.91	13.12	8.39
Rice flour	100	12.17	85.25	0.25	19.85	0.037	15.17	48.97	10.15
Cashew apple pomace powder	100	19.59	40.35	0.96	8.23	15.75	80.83	38.38	--
Rice + Green gram	60:40	22.65	71.91	2.43	160.43	0.09	14.23	52.93	10.31
Rice + Green gram + Pomace	60:35:5	22.95	69.85	2.08	116.43	0.56	15.42	46.97	10.74
Rice + Green gram + Pomace	60:30:10	20.88	64.58	2.08	113.34	1.27	13.72	49.90	10.31
Rice + Green gram + Pomace	60:25:15	22.51	80.21	1.40	39.89	2.34	20.23	23.07	8.04
Rice + Green gram + Pomace	60:20:20	20.39	84.16	1.30	35.49	3.19	20.79	7.76	7.49
Wheat + Green gram	60:40	25.36	62.67	3.43	105.53	0.78	15.49	41.36	7.64
Wheat + Green gram + Pomace	60:35:5	24.14	60.33	4.79	83.75	1.51	19.65	56.38	7.63
Wheat + Green gram + Pomace	60:30:10	17.38	67.26	2.43	93.45	2.37	18.55	470.9	3.69

Wheat + Green gram + Pomace	60:25:15	17.30	75.31	2.42	35.17	2.99	20.79	51.17	3.66
Wheat + Green gram + Pomace	60:20:20	24.28	71.85	4.89	26.29	3.82	22.63	88.62	5.81
Ragi + Green gram	60:40	19.81	66.78	2.11	107.77	1.74	57.74	37.12	4.73
Ragi + Green gram + Pomace	60:35:5	22.02	64.63	3.48	78.10	3.02	65.1	74.11	4.09
Ragi + Green gram + Pomace	60:30:10	17.38	67.26	2.43	93.45	3.99	66.85	40.9	3.69
Ragi + Green gram + Pomace	60:25:15	17.30	75.31	2.42	35.17	3.73	79.65	51.17	3.66
Ragi + Green gram + Pomace	60:20:20	16.30	76.43	2.11	55.14	4.39	91.82	43.18	3.30

Values are mean of three individual estimations

Table 7.27: Storage studies of the blends

Sample	Bulk Density (g/cc)*			Moisture content (%)*			Water absorption capacity (%)*			Consistency Pat spread (cm)*			Crude Fibre (%)*		
A	0.8	0.7	0.7	2.1	4.1	6.2	42	53	51	6.8	7	4.1	0	0.3	0.6
B	0.8	0.7	0.7	1.7	2.8	4.8	47	58	53	5.4	7.0	4.1	0.6	0.7	0.8
C	0.7	0.6	0.7	2.7	2.9	5.2	38	51	50	8.9	5.7	5.1	1.1	0.8	1.1
D	0.7	0.7	0.6	2.3	2.2	4.8	39	41	47	7.9	5.7	3.9	1.8	2.2	1.4
E	0.7	0.7	0.7	2.2	2.9	5.3	48	49	47	11	5.7	8.3	1.5	1.5	1.6
F	0.7	0.7	0.7	2.0	2.0	4.2	40	48	50	9.7	7.8	7.2	1.9	4.2	1.8

* Storage time given in 0, 6 and 12 months respectively in each parameter

Table 7.28: Biochemical changes during storage of flour blends at ambient temperature

Flour blends	Storage period (months)	Protein (mg/100 mg)	Starch (mg/100 mg)	Tannin (µg/100 mg)	Peroxides (n moles/g MDA)	Phylic acid (µg/100 mg)	In vitro digestibility	
							Protein (%)	Starch (mg maltose/3h/100 mg)
Rice + Green gram (60:40)	0	15.15	76.28	24.67	3.97	110.41	37.16	13.38
	2	14.45	78.85	21.10	2.64	97.32	57.48	12.71
	4	13.82	75.15	27.30	5.04	74.48	87.03	11.79
	6	14.36	74.88	42.45	6.06	103.44	71.67	13.55
	8	14.93	81.79	41.43	5.84	230.00	59.67	14.31
	10	20.05	79.94	33.76	6.49	105.67	57.20	11.34
	12	20.42	81.01	87.48	4.80	146.04	43.37	8.65
CD (5%)	1.706	3.969	7.070	0.625	7.041	13.347	0.896	
Rice : Green gram : Cashew apple pomace (60:30:10)	0	11.85	74.31	17.92	3.27	116.69	43.59	13.87
	2	15.01	78.82	11.25	1.83	81.07	58.65	12.29
	4	14.00	75.00	19.36	4.24	27.31	83.60	10.46
	6	15.63	72.76	33.40	6.28	4.42	47.96	13.49
	8	16.31	86.67	30.15	5.29	173.21	61.23	14.24
	10	19.82	77.51	25.66	5.70	88.61	35.23	11.25
	12	17.22	83.00	89.27	4.52	97.86	68.33	8.83
CD (5%)	1,702	3.751	3.025	0.972	4.061	11,361	1.139	
Wheat + Green gram (60:40)	0	15.25	72.99	12.90	4.04	145.60	43.41	6.79
	2	16.54	71.11	9.51	3.73	91.69	70.37	6.24
	4	15.70	68.64	17.73	7.55	27.04	75.27	5.43
	6	18.06	60.15	36.00	11.56	105.88	31.23	3.06
	8	14.35	74.49	31.38	10.50	325.32	84.83	7.19
	10	21.77	74.13	24.27	11.20	177.41	71.40	4.73
	12	22.35	70.27	68.06	10.41	178.99	52.30	4.44
CD (5%)	1.852	8.097	1.509	0.692	16.638	8.24	0.485	

Wheat + Green gram + Cashew apple pomace (60:30:10)	0	15.67	80.07	12.35	3.53	108.79	54.20	7.25
	2	14.36	72.79	7.03	3.20	52.28	64.93	5.97
	4	15.64	74.78	17.73	7.69	54.01	83.57	5.24
	6	19.72	70.86	33.67	10.03	50.03	45.77	3.06
	8	20.45	70.29	35.31	10.95	225.60	53.13	7.87
	10	21.32	74.83	17.12	10.21	133.34	48.37	5.38
	12	19.38	73.32	69.71	9.43	161.87	48.87	4.82
	CD (5%)	1.786	3.484	2.739	1.211	13.789	11.873	0.276
Ragi + Green gram (60:40)	0	14.84	75.84	40.01	3.79	123.29	45.50	3.97
	2	15.68	69.41	28.13	2.74	70.40	54.22	3.33
	4	14.30	48.08	45.02	6.06	37.73	80.70	3.42
	6	16.15	71.43	87.00	9.65	33.99	57.23	3.11
	8	17.13	67.49	64.74	7.62	263.30	48.47	4.21
	10	23.97	73.90	60.63	9.13	68.38	41.30	2.95
	12	17.75	74.84	137.92	6.41	189.97	68.97	2.55
	CD (5%)	2.025	5.083	4.217	NS	18.696	12.141	0.250
Ragi + Green gram + Cashew apple pomace (60:30:10)	0	12.75	69.68	41.59	3.68	130.42	60.52	3.57
	2	12.65	73.24	29.52	2.62	88.36	55.62	3.67
	4	13.08	74.24	48.26	5.09	43.52	85.60	2.96
	6	13.88	68.84	75.80	8.09	24.76	77.37	2.68
	8	14.05	67.61	58.49	6.42	214.63	46.10	3.90
	10	16.51	73.56	45.77	8.06	86.16	53.43	3.02
	12	18.86	75.27	127.59	6.06	125.76	48.90	2.95
	CD (5%)	2.195	NS	6.748	0.547	12.072	15.374	0.222

Values are mean of three individual estimations

Table 7.29: Composition of cashew apple pomace crude fibre (%)

Constituent	Fibre		
	A	B	C
Protein (Nx6.75)	0.64	10.94	23.55
Carbohydrate	13.64	12.29	5.37
Total Sugars	0.095	0.080	0.062
Tannin	-	-	-
In vitro digestibility of			
Carbohydrate*	0.821	ND	ND
Protein	10.0	20.27	14.06
Water absorption capacity	504.00	220.7	265.7

- A - Cashew apple pomace without fermentation
 B - Cashew apple pomace after fermentation
 C - Cashew apple pomace after fermentation and growing
 Pleurotus
 * - Expresses as mg maltose released/3h/100 mg
 ND - Not detected
 Values are mean of three individual estimations

Table 7.30: Composition of cashew kernel testa.

Constituents	A	B
Protein (N x 6.25)	20.45	37.11
Carbohydrate	10.83	16.11
Sugars	15.04	7.59
Tannins	72.22	11.33
In vitro digestibility		
Carbohydrate*	4.34	3.36
Protein	12.43	10.45
Water absorption capacity	180.4	268.4

- A - Cashew kernel whole testa
 B - Methanol extracted cashew kernel testa
 * - Expresses as mg maltose released/3h/100 mg
 Values are mean of three individual estimations

Table 7.31: Composition of cashew shell crude fibre (%)

Constituent	A	B	C
Protein (Nx6.75)	0.57	0.11	0.11
Carbohydrate	50.39	52.99	41.80
Total Sugars	0.049	0.047	0.055
Tannin	-	-	-
In vitro digestibility of			
Carbohydrate*	0.185	0.224	0.439
Protein	100	100	100
Water absorption capacity	559	642	561

- A - Methanol extracted whole cashew shell powder
B - Methanol extracted CNSL expelled cashew shell cake
C - Water extracted CNSL expelled cashew shell cake
* - Expresses as mg maltose released/3h/100 mg
Values are mean of three individual estimations

7.6: Impact of Transfer of Technology in Cashew Cultivation

Project Leader	:	Dr. R. Venkattakumar
Project Associate	:	Dr. T.N. Raviprasad (2001-04) Dr. M.G. Nayak (2002-04)
Project Number	:	5.2
Project Duration	:	3 years (2001-2004)

7.6.1 Introduction

Various transfer of technology efforts viz., laying out demonstration farms at farmers fields, organizing thematic campaigns, organizing cashew field / cashew days and day long training programmes are being followed to disseminate the technologies developed by Research Centre. Assessing the impact of these modes provide an idea about the extent of acceptance of the recommended technologies by the farmers and strategies to refine the recommended technologies as well as modes of transfer of technology employed.

7.6.2 Objectives

- i) To assess the impact of various modes of transfer of technology viz., demonstration plots, cashew day, thematic campaigns and training programmes.
- ii) To assess the impact of various technologies transferred.
- iii) To delineate suggestions to refine the technologies transferred and modes of transfer of technology.

7.6.3 Material and Methods

The data were collected by applying purpose sampling procedure, from demonstration farmers, farmers who attended the thematic campaigns, farmers who attended earlier cashew days, participants of the “Cashew apple utilization” training programmes, extension personnel who are working in cashew growing districts of Karnataka and researchers / scientists

who are working on cashew. A total of 60 demonstration farmers, 40 farmers who attended earlier cashew days, 60 farmers who attended earlier thematic campaigns, 51 farm women who participated in the training programmes of cashew apple utilization and research / extension personnel (40) were contacted through standardized interview schedule / mailed questionnaire.

Two teacher-made scales were developed in order to assess the perceived opinion of the farmers towards SWC and PP measures of cashew cultivation. The scale developed for SWC measures originally had 20 statements (12 positive and eight negative statements) and the scale developed for PP measures had 17 statements (eight positive and nine negative statements). These two scales were standardized by rating the developed statements against a five point continuum (Most Relevant, Relevant, Undecided, Irrelevant, Most Irrelevant). After standardization of the scales the number of statements selected for SWC and PP measures were 12 (all positive statements) and seven (six positive and one negative) respectively. The opinion of the farmers were collected using a five point continuum (Strongly agree, Agree, Undecided, Disagree, Strongly Disagree). The developed scale was translated into Kannada for better understanding while administering the tool.

7.6.4 Results and Discussion

7.6.4.1 Profile of respondents

Majority of the demonstration farmers belong to old age category whereas, cashew day and campaign farmers belong to young to middle age category. Majority of the respondents had middle school to collegiate level of education and agriculture as primary occupation. Demonstration farmers had high level of farming experience whereas, others had low to medium level of farming experience. As far as experience in cashew cultivation is concerned majority of farmers had low or low to medium level of experience. Majority farmers had other crops (coconut, arecanut, cocoa, pepper, paddy, banana) besides cashew.

7.6.4.2 Impact of demonstration plots

Majority of the demonstration farmers adopted the recommended planting technology, SWC measures, initial training and control measures against TMB. They adopted the recommended dosage of fertilizer application during the subsidy period, but there after they did not follow the recommended dosage of fertilizers and modified according to their convenience. The adoption behaviour of demonstration farmers towards CSRB was very low (Table 7.32). Discontinuance of the technologies after the subsidy period is over indicates the secondary preference given by these farmers to cashew compared to other plantation crops.

7.6.4.3 Impact of thematic campaigns

Majority of the farmers who attended the thematic campaigns had knowledge towards recommended SWC measures and control measures against TMB and CSRB. Their adoption behaviour towards control measures against CSRB was very low whereas, those farmers who observed the symptoms of attack of TMB applied insecticides to control the pest (Table 7.32). The campaigns were effective in imparting knowledge to the respondents in SWC / PP measures where the number of respondents having higher level of knowledge was more after the training compared to that of before the training (Table 7.33).

7.6.4.4 Impact of Cashew Day

The knowledge level and adoption behaviour of the farmers who attended the cashew day / field day was quite low against all the recommended cashew cultivation practices compared to that of demonstration farmers. It could be explained that such programmes are only to create awareness among more number of farmers about the recommended technologies and hence the adoption behaviour of these farmers observed are low (Table 7.33).

7.6.4.5 Impact of cashew apple utilization training programmes

Most of the respondents who were contacted both through mailed and post-exposure questionnaire preferred jam and juice/squash, based on the taste. Based on the ease in understanding, majority of the respondents (60.00%) who were contacted through post-exposure questionnaire preferred jam. Home level symbolic adoption of respondents who were contacted through post-exposure questionnaire was more towards all the demonstrated products whereas, large scale symbolic adoption of them was more towards jam (80.65).

Home level adoption of the respondents who were contacted through mailed questionnaire was more or less similar for all the products i.e., jam (55.00%), squash/juice (65.00%) and chutney (45.00%), whereas the large scale adoption of them was poor towards all products i.e., jam (15.00%), juice/squash (5.00%) and chutney (5.00%).

The respondents who were contacted through mailed questionnaire listed out the following reasons for not having adopted the demonstrated products at home level viz., no facilities at home, no adequate time to try these products and non-availability adequate cashew apples, whereas the reasons quoted by them for not having adopted at large scale are, no awareness about the information about establishment of small scale units, no adequate facilities, non-availability of adequate quantity of cashew apples, no adequate time, poor economical background and marketing problems.

It could be concluded that taste wise both jam and squash/juice were preferred whereas based on the ease in understanding, squash/juice was preferred by the respondents who were contacted through mailed questionnaire though the respondents contacted through post-exposure questionnaire preferred jam. Since the first category of respondents have experience in preparation of these products at home level, it could be concluded that juice/squash is easy to prepare for the respondents. The large scale adoption of demonstrated products was poor due to the above mentioned reasons in spite of the adoption level was around 50% for all products at home level.

7.6.4.6 Perception of demonstration farmers towards recommended soil and water conservation and plant protection measures

Most of the respondents had average to more level of favourable perceived opinion towards the recommended soil and water conservation and plant protection measures (Table 7.34). It implies that most of the respondents adopted the recommended SWC measures viz., terracing and opening of catch pits and experienced the impact of adopting such SWC measures. At the same time the coconut husk burial technology was not adopted by the farmers and all the recommended soil and water conservation practices are costlier to adopt as felt by the demonstration farmers (Table 7.35). As far as plant protection measures are concerned, more than half of the respondents were convinced about the control measures against TMB. But at the same time due to the difficulty in identification, locating and management of CSRB, the respondents did not adopt the CSRB control measures, and so the undecided response was more towards the statements about CSRB control (Table 7.36).

7.6.4.7 Reasons responsible for the yield gap in cashew and suggestions to refine the extension modes (Farmers' response)

Climatic conditions mainly cloudy weather, non adoption of recommended practices, tea mosquito attack during the flowering and fruiting seasons, below average performance of the cashew varieties, attack of CSRB, theft problem during harvest, irregular flowering and poor soil fertility were some of the reasons responsible for the yield gap as quoted by farmers. Explaining the technologies through method demonstration, more number of visits to the demonstration plots during the seasons, more extension programmes at farmers' plots, more number of displays about the control of CSRB, maximum time allotment for discussion during the programmes and explaining the technologies through video show, more number of displays for exhibition, more time for visit to experimental / progressive farmers plot, keeping displays at respective fields and use of local language at extension

programmes were some of the suggestions told by the farmers to refine the extension modes.

7.6.4.8 Constraints in adopting recommended cashew cultivation practices, reasons for yield gap in cashew

Lack of knowledge about improved recommended practices, small and marginal cashew growers who cannot afford to management practices with less productivity, drought, pest damage etc were the constraints in adopting recommended cashew cultivation practices by the farmers as told by researchers /extension personnel. Non-use of grafted planting material, recommended fertilizers, control measures against TMB and CSRB, senile and unproductive cashew gardens, no organized support for cashew replanting, insufficient extension programmes in cashew, farmers treat this crop as neglected crop and unpredictable pest outbreak etc were some of the reasons for yield gap in cashew as told by researchers / extension personnel.

7.6.4.9 Suggestions to overcome the constraints (Response from researchers / extension personnel)

Identification of resistant varieties against cashew pests, support for irrigation in cashew, organizing more thematic campaigns, popularizing the small scale processing units for value addition and employment generation training programmes at interior villages to educate economically backward cashew growers and larger area demonstration of popular cashew varieties are the suggestions offered by the extension workers / researchers to overcome the constraints faced by the farmers and yield gap in cashew.

7.6.5 Conclusions

- Even though the impact of demonstration plots, thematic campaigns and cashew days was felt much, the continued adoption of the recommended practices by the farmers was not recorded due to the secondary preference given by them to this crop.

- Thematic campaigns are very effective in transferring recommended technologies of cashew to the farmers through intensive training.
- The adoption behaviour of cashew growers towards recommended control measures against CSRB was recorded low.
- The large scale adoption of recommended cashew apple utilization techniques was low among the participants (farm women).

Table 7.32: Adoption behaviour of respondents towards recommended cashew cultivation practices.

(N=160)

Practices recommended	% of adoption		
	DF (n=60)	CDF (n=40)	CF (n=60)
Recommended spacing	100.00	62.50	NA
Recommended pitsize	100.00	62.50	NA
Application of FYM	96.67	37.50	NA
Application of rock phosphate	95.00	25.00	NA
Staking	100.00	52.00	NA
Terracing	83.33	67.50	85.00
Opening of catch pits	68.33	52.25	85.00
a) Recommended does of chemical fertilizers upto subsidy period	95.00	NA	NA
b) Contiued adoption	25.00	NA	
Application of FYM	78.33	50.00	NA
Application of poultry manure	28.33	40.00	NA
Correct method of fertilizer application	95.00	10.00	NA
Mulching	95.00	82.50	NA
Initial training	61.67	35.00	NA
Control measures against TMB	76.67	37.50	91.67
Control measuers against CSRB	18.35	21.67	10.00

DF: Demonstration Farmers CDF : Cashew Day Farmers CF: Campaign Farmers

Table 7.33: Effectiveness of thematic campaigns on SWC / PP measures

(N= 128)

Category of knowledge level	Pre-evaluation		Post-evaluation	
	No.	%	No.	%
Low	24	18.75	1	0.78
Medium	73	57.03	58	45.31
High	31	24.22	69	53.91
Total	128	100.00	128	100.00

Table 7.34: Distribution of demonstration farmers according to their favourable perceived opinion towards recommended SWC / PP measures in cashew

(N=50)

Category of favourableness	Number
SWC measures	
Less	5 (10.00)
Average	34 (68.00)
More	11 (22.00)
Total	50 (100.00)
PP Measures	
Less	5 (10.00)
Average	34 (68.00)
More	11 (22.00)
Total	50 (100.00)

Figures in bracket indicate the extent as percentage.

Table 7.35: Statement wise perceived opinion of demonstration farmers towards recommended SWC measures.

(N=50)

Statements	Favourable No.	Undecided No.	Unfavourable No.
Soil and water conservation measures increase the water availability to the cashew crop	48 (96.00)	0 (0.00)	2 (4.00)
Soil and water conservation measures are easy enough to be adopted under cashew cultivation	43 (86.00)	1 (2.00)	6 (12.00)
The technologies of soil and water conservation measures recommended for cashew are easily understandable	50 (100.00)	0 (0.00)	0 (0.00)
By adopting terraces at the base of the cashew trees considerable quantity of water can be conserved during the monsoon season	44 (88.00)	2 (4.00)	4 (8.00)
Terraces not only serve as water conservation but also as measures to arrest the soil erosion.	46 (92.00)	2 (4.00)	2 (4.00)
Coconut husk burial as a soil and water conservation measure is an easy as well as cheaper technology	15 (30.00)	34 (68.00)	1 (2.00)
The number of days in which the soil moisture is available to cashew crop is increased due to soil and water conservation measures	50 (100.00)	0 (00.00)	0 (0.00)
Forming terraces at the base of the cashew crop improved the soil structure	47 (94.00)	2 (4.00)	1 (2.00)
Opening of catch pits and coconut husk burial are effective in controlling soil erosion	21 (42.0)	29 (58.00)	0 (0.00)
For cultivating cashew in sloppy lands, terraces form as effective structures for conservation of soil and moisture	45 (90.00)	3 (6.00)	2 (4.00)
Under steep sloppy areas, cultivating cashew in contour bunds is an effective soil and water conservation method	38 (76.00)	8 (16.00)	4 (8.00)
The effect of soil and water conservation measures under cashew garden is clearly visible	44 (88.00)	3 (6.00)	3 (6.00)

Figures in bracket indicate the extent as percentage.

Table 7.36: Statement-wise perceived opinion of demonstration farmers towards recommended plant protection measures.

(N = 50)

Statements	Favourable	Undecided	Unfavourable
	No.	No.	No.
The recommended plant protection measures against tea mosquito bug are effective	28 (56.00)	16 (32.00)	11 (22.00)
The effect of recommended plant protection measures are clearly visible	24 (48.00)	19 (36.00)	7 (14.00)
The yield of cashew increased when recommended spray schedule against the tea mosquito bug was adopted	23 (46.00)	20 (40.00)	7 (14.00)
The recommended control measures could not check the attack by cashew stem and root borer	21 (42.00)	21 (42.00)	8 (16.00)
Carbaryl treatment against CSRB is an effective method	5 (10.00)	39 (78.00)	6 (12.00)
Field sanitation provides better result in controlling CSRB attack	26 (52.00)	23 (46.00)	1 (2.00)
In general, recommended control measures to control CSRB are easy to understand and adopt	26 (52.00)	22 (44.00)	2 (4.00)

Figures in bracket indicate the extent as percentage

7.1: Computerized Information Management System for Cashew

Project Leader	:	Mr. P.D. Sreekanth
Project Associate	:	Dr. E.V.V. Bhaskara Rao (June 2001 to March 2003)
Project Number	:	6.1
Project Duration	:	3 years (2001-2004)

7.7.1 Introduction

Cashew (*Anacardium Occidentale* L.) is an important earning cash crop of India. It is commercially grown for its kernels, although cashew nut shell liquid (CNSL) and apples are also valuable byproducts. The total raw cashewnuts production of 5.06 lakh tonnes in India is lower than the demand from processors.

Nevertheless, the global trade scenario is changing very fast. India's raw nut production is not sufficient to sustain the processing capacity established in the country. India has been importing raw nuts from African countries to bridge the gap. As many of these African countries have already started strengthening their processing capacities and the increased production of raw nut by South East Asian countries, it is imperative that India has to increase its raw nut production to sustain itself in the international market. The present study was initiated with the following objectives.

7.7.2 Objectives

- i) To develop a query based database for cashew information.
- ii) To develop a forecast model for cashew yield

7.7.3 Materials and Methods

The secondary data on area and production was collected from Directorate of Cashew nut and Cocoa Development (DCCD) and Cashew Export Promotion Council (CEPC), Kochi for the period from 1965-66 to 2002-03 for all the cashew growing states. Data on 2003 for area production, cashew

kernel export and import of raw cashew nuts for different cashew growing countries for the year 1961-2003 was collected from FAO.

Regarding database package, backend database is Microsoft Access and front end tool is Visual Basic 6.0. To store data in systematic way and avoid duplication of data, normalization techniques were used to create database tables. By using Visual Basic 6.0, user interface forms were developed. All forms are inter linked with each other. These forms are menu driven and user friendly. The main menu provides options like data entry, data modification/deletion and reports. Under data entry option, different forms provide different types of data entry like world cashew information, country wise cashew information, information on major and minor states of cashew producing in India, import of cashew raw nuts (country wise) and export of cashew kernel and CNSL (country wise). By using data modification/deletion option user can update or delete the existing information on above aspects. The reports option provide different types of data reports based on the user queries. It also provide both in numerical and graphical representation reports.

7.7.4 Results and Discussion

The data flow diagram for query based database for cashew information is given in Fig.7.1. The efforts were made to develop a regression equations to predict yield, based on available variables viz., cultivated area and production along with derived variables viz., growth rate of cultivated area, incremental area, average productivity, approximate initial three years new area under cashew. This model is a function of five variables i.e.

$$Y_n = f [A_1, A_2, A_3, P_1, P_2]$$

Where:

- | | | |
|----|---|--|
| A1 | = | Estimated area under cashew for n th year |
| A2 | = | Previous six years incremental area |
| A3 | = | 1 st , 2 nd and 3 rd harvest area |
| P1 | = | Five years moving average for productivity |
| P2 | = | Two years moving average for Production growth rate |

A1 is the estimated cashew area for the n^{th} year for which the yield estimate has to be worked out. This is calculated by taking average of growth rate for previous five years. The annual growth rate of cultivated area is calculated as follows.

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

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

* C.A = cultivated area

As yield of cashew does not stabilize up to six years of planting, variable A2 (six years incremental area) is incorporated to minimize the error.

A3 is the sum of 4th, 5th and 6th year old cashew plantation area. Considering the fact that cashew gives minimal yield in 4th, 5th and 6th years (1st, 2nd and 3rd harvest).

P1 is the moving average of productivity for the previous five years. In order to get an accurate estimate of yield, n^{th} year productivity was calculated by deducting incremental area for previous three years from n^{th} year total cultivated area. The productivity of n^{th} year is calculated using the following formula.

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

The variable P2 is the two years moving average on production growth rate. In view of high speculation of production over the years, ($n-2$) years growth rate on production is included to arrive at a better model. By trial and error method, average growth rate for 1, 2, 3, 4 and 5 years were tried and tested for regression coefficient. It is found that, the estimated yield when

calculated using the above model by substituting 2 years average growth rate of production resulted in higher R² values.

$$P2 = \sum_{i=1}^2 \sum_{j=2}^3 [(((n-i)Y.P^* - (n-j)Y.P / (n-j)Y.P)) / 2]$$

*Y.P Year Production

Based on the above variables the regression equations for various states were formulated (Table 7.37). Last five years cumulative state-wise area under cashew and production estimation are given in Fig.7.2 and 7.3 respectively. Last five years cumulative error variation is very less (Table 7.38).

7.7.5 Publication

Sreekanth, P.D. and Bhaskara Rao, E.V.V. 2003. Model for forecasting yield of cashew. *The Cashew*. XVII(4): 23-31.

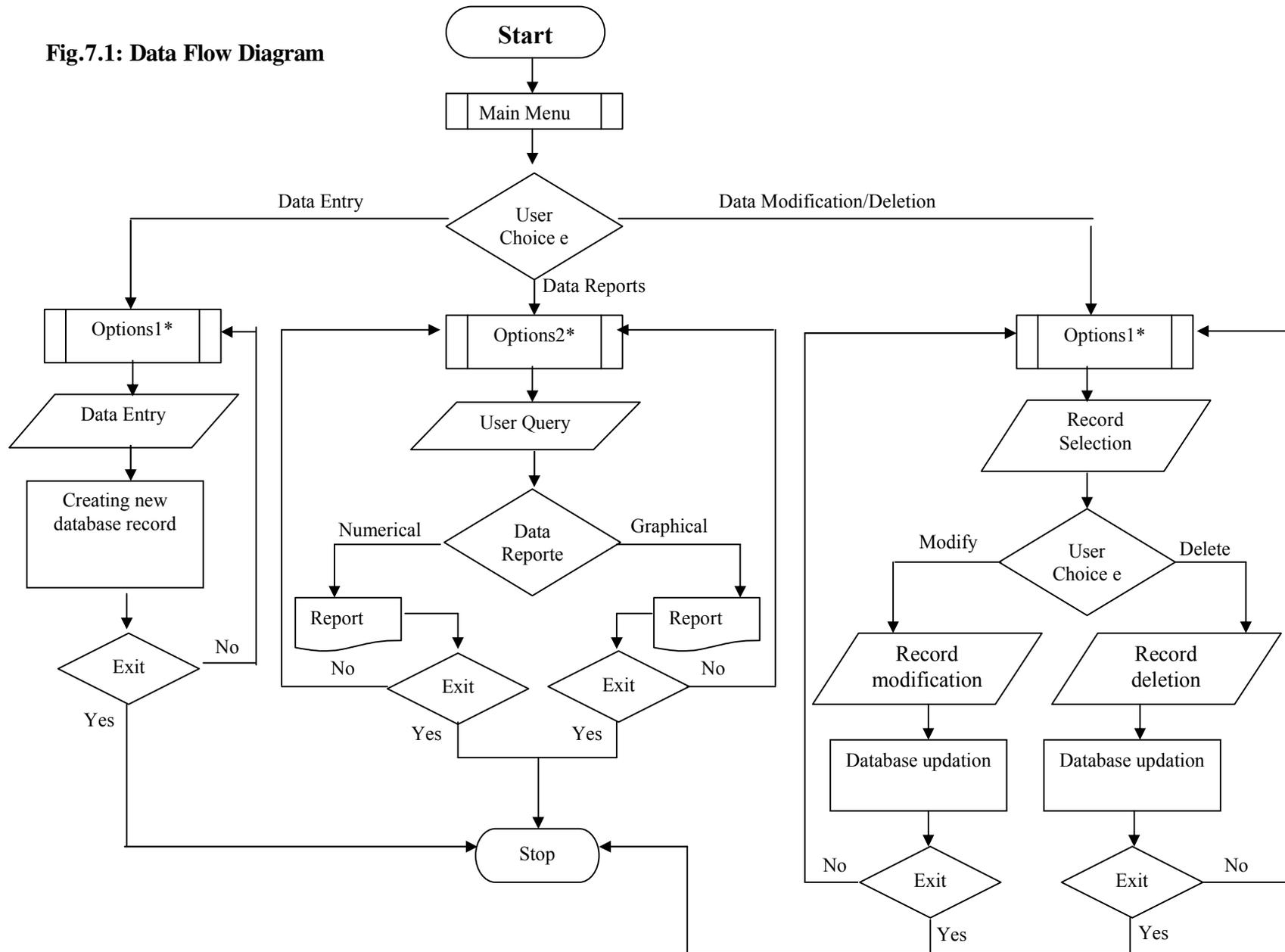
Table 7.37: Statewise cashew yield prediction equations

State Name	Regression equation	R ² Value
Andhra Pradesh	$Y_n = -43025 + (0.397 * A1) - (0.380 * A2) - (0.576 * A3) + (114376 * P1) + (39864 * P2)$	0.97
Goa	$Y_n = -5138 - (0.038 * A1) + (0.248 * A2) - (0.002 * A3) + (75238 * P1) + (1312 * P2)$	0.98
Karnataka	$Y_n = -20584 + (0.478 * A1) - (0.464 * A2) - (0.152 * A3) + (48790 * P1) + (8795 * P2)$	0.87
Kerala	$Y_n = -74371 + (0.934 * A1) + (0.573 * A2) - (1.900 * A3) + (71890 * P1) + (85078 * P2)$	0.86
Maharashtra	$Y_n = -11575 + (0.489 * A1) - (0.167 * A2) - (0.349 * A3) + (37081 * P1) - (13045 * P2)$	0.94
Orissa	$Y_n = -16231 + (0.484 * A1) - (0.239 * A2) - (0.415 * A3) + (48068 * P1) + (2455 * P2)$	0.98
Tamil Nadu	$Y_n = -53653 + (0.473 * A1) + (0.011 * A2) - (0.575 * A3) + (175570 * P1) + (11334 * P2)$	0.89
West Bengal	$Y_n = -4200 + (0.783 * A1) - (0.731 * A2) - (0.337 * A3) + (5936 * P1) + (5.840 * P2)$	0.65
Others	$Y_n = -54.60 + (0.270 * A1) - (0.118 * A2) + (0.534 * A3) - (11.433 * P1) - (2.987 * P2)$	0.99

Table 7.38: Error variation between actual and estimated area and yield of cashew

Year	Error Variation %	
	Area	Yield
1998-99	-10.46 %	12.30 %
1999-2000	-12.06 %	4.47 %
2000-01	-5.01 %	-15.33 %
2001-02	-2.71 %	-7.65 %
2002-03	-4.23 %	4.40 %

Fig.7.1: Data Flow Diagram



***Options1 :**

1. World Cashew Information
2. Country wise Cashew Information
3. Domestic (State wise) Cashew Information
4. Import of Raw nut Information
 - a. Total
 - b. Country wise
5. Export of Cashew Kernels Information
 - a. Country wise
 - b. From India
6. Export of CNSL Information

*** Options2 :**

1. World Cashew Information
2. Country wise Cashew Information
3. Domestic (State wise) Cashew Information
 - Numerical
 - a) Year wise
 - b) State wise
 - Graphical
4. Import of Raw nut Information
 - a. Total
 - b. Country wise
5. Export of Cashew Kernels Information
 - a. World Info.
 - b. Country wise
 - c. From India
6. Export of CNSL Information
 - Numerical
 - a) Country wise
 - b) Year wise
 - Graphical

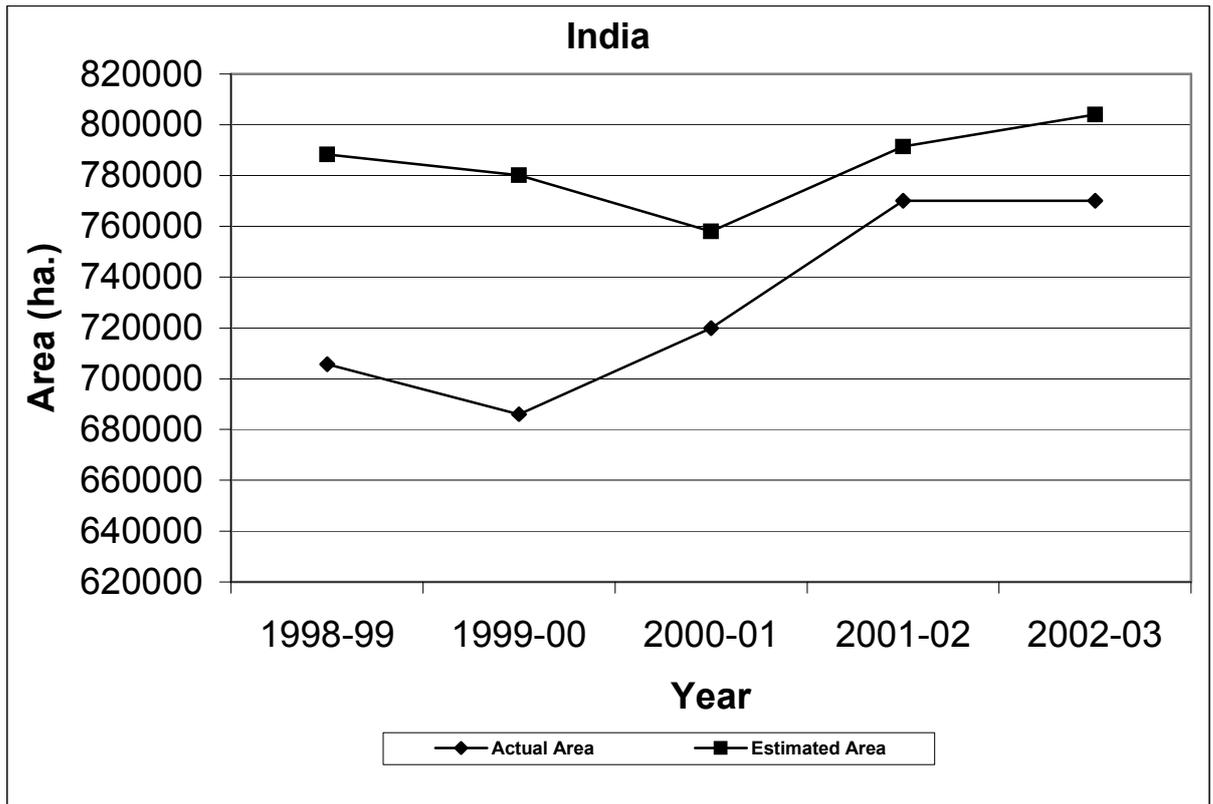


Fig.7.2: Actual Vs Estimated values for area under cashew from 1998-99 to 2002-03

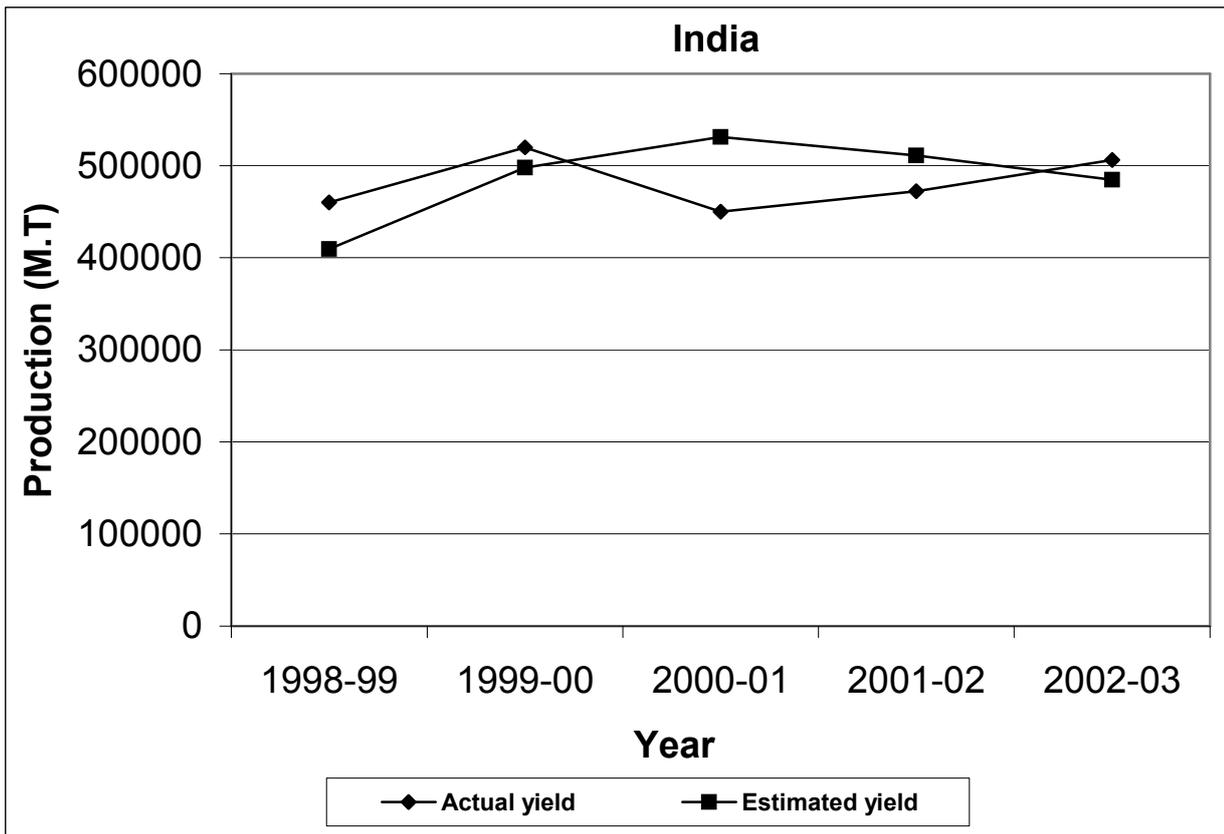


Fig.7.3: Actual Vs Estimated values for cashew production from 1998-99 to 2002-03

7.8: Developing integrated production package for enhancing productivity of cashew (NATP)

Principal Investigator	:	Dr. N. Yadukumar
Co-Principal Investigator	:	Dr.T.N. Raviprasad, Dr. K.V. Nagaraja, Dr. B.B.Sapkal, Dr. S.K. Godase, Dr.(Mrs) Susanamma Kurien, Dr. G. Gajendran, Dr. P.C. Lenka, Dr. R.N. Mohapatra and Dr. B. Bandyopadhyay
Project Number	:	NATP
Project Duration	:	3 years (2001-2004)

7.8.1 Objectives

- i) Nutrient budgeting and balance studies through system approach in high density planting of cashew.
 - To study and quantify the various processes involved in nutrient enrichment, nutrient depletion, and working out economics of the system
- ii) Organic farming technology for utilizing organically recyclable biomass for integrated nutrient management.
 - Developing technique for generating green biomass, evaluating intercrops in cashew garden and nutrient release pattern of compost and its quality, possibility of enriching compost with bio-fertilizers, use of compost as carrier for bio-fertilizers, working out economics of integrated approach of both organic and inorganic farming systems.
- iii) Management of on cashew stem and root borer (CSRB)
 - To test efficacy of phytosanitary measures on level of infestation by the pest to maintain optimum plant density in cashew orchards.

- To identify effective post treatment prophylaxis for checking reinfestation
- To investigate response of CSRB to different plant parts and identifying the response inducing kairomones.
- To investigate presence of sex/aggregation pheromones in CSRB and attempting to synthesize the same

7.8.2 Results

7.8.2.1 Nutrient budgeting and balance studies through system approach in high density planting of cashew.

- Organically recyclable cashew biomass (ORCB) available in cashew garden yearly in fertilizer-applied plots was 5.51 to 6.12 t/ha at Puttur, 2.92 to 3.04 t/ha at Vengurle, 6.25 to 7.63 t/ha at Bhubaneshwar and 3.17 to 4.03 t/ha at Vridhachalam.
- If this ORCB is allowed to decompose *in situ* in the field it contributes the major nutrients as given in Table 7.39.
- No significant difference in yield among different fertilizer doses (1162-1284 kg/ha.) and 1/3rd to 1/2 dose is sufficient to meet the nutrient requirement in all the centers
- Highest profit was realized in plot receiving 1/3rd dose of fertilizers at Puttur and 1/2 dose in Bhubaneshwar and Vridhachalam
- Nine farmers adopted this technique in and around Puttur and found high-density planting with revised dose of fertilizes successful. With this total cost of Rs. 2,875/ha/year can be saved. This is also demonstrated in KCDC Plantations in 25 acres area.

7.8.2.2 Organic farming technology for utilizing organically recyclable biomass for integrated nutrient management.

- The green manure crop Glyricidia contributed highest quantity of nutrients, which is equal to 186 kg N, 40.8 kg P₂O₅ and 67.8 kg K₂O/ha at Puttur. At Vengurle, Sesbania contributed highest green biomass which contributed 75 kg N, 10kg P₂O₅ and 14kg K₂O /ha.
- Turmeric and cucumber fetched higher profit as intercrops (Table 7.40).
- Biofertilizer-Azospirillum with compost of organically recyclable biomass available in cashew garden recorded highest yield (1053 kg/ha) and profit (Rs. 28,601) followed by 50 and 75 % N of recommended dose applied in inorganic form and remaining applied in the form of composted organically recyclable biomass (NRCC, Puttur).
- At Vengurle application of recommended dose of fertilizers in inorganic form (1860 kg/ha) or combination of poultry manure(75% N) and inorganic manure(25% N) gave highest yield(1730 kg/ha) and profit.
- At Vridhachalam, 75% N applied in the form of inorganic manure and remaining applied in the form of composted organically recyclable biomass available in cashew garden recorded highest yield (1030 kg/ha) fetching maximum profit (Rs. 22,562/ha).
- After six months recyclable biomass + 20% cow dung slurry and recyclable biomass + urea (0.5%) + 1.25 kg rock phosphate gave minimum C: N ratio of 10 and 11.16 compared to 16.13 to 21.76 in other treatments.

- Highest colony forming units (cfu) of bacteria (21×10^6) were observed in treatment recyclable biomass + 20% cow dung slurry. Lowest was in recyclable biomass alone (13×10^6).
- Highest cfu of fungi was found in treatment recyclable biomass + rock phosphate (38×10^4) and lowest (18×10^4) in recyclable biomass + urea + rock phosphate. Highest cfu (15×10^5) of actinomycetes was found in recyclable biomass + rock phosphate treatment.
- In an adult plantation, cashew biomass collected ranged from 5.0 to 5.5 t / ha. Considering 60 - 65% recovery, total mature compost will be 3.5 to 3.7 t / ha. Thus 46 to 69% N, 25 to 87% P_2O_5 and 13% K_2O of nutrient requirements of adult cashew orchard can be met from the compost of recyclable biomass.
- If entire quantity of the recyclable biomass is used for composting, the consequent organic manure produced can substantially substitute the inorganic fertilizer demand of cashew thus making the plantation system self-sustainable economically.
- Total cost of producing compost from recyclable cashew biomass is Rs. 500/ton.
- Addition of cow dung slurry, urea and phosphorus solubilizer enhances the decomposition of biomass within six months.
- Colony forming units of bacteria (39×10^6), fungi (38.8×10^6), actinomycetes (28.0×10^6) and *Azospirillum* (0.516×10^4) were found in treatment receiving 15% cow dung slurry.
- The cashew biomass fallout from cashew garden when treated with cow dung slurry (15% of total weight) could be converted into vermicompost within three months by earthworm (*Eudrilus* sp).

- Organically recyclable biomass (2 tons) could be converted into 1.3 ton of vermicompost with net recovery of 65 %.
- Vermicompost thus produced was rich in Organic Carbon (11.91%), N (1.2%), P (0.9%), K (0.6%), Ca (2.75%), Mg (0.80%) and micronutrients like Fe (162 ppm), Mn (24.5 ppm), Cu (12.4 ppm) and Zn (29.7 ppm)
- Total cost of production of vermicompost from recyclable cashew biomass is Rs.1100/ton.

7.8.2.3 Management of CSRB

7.8.2.3.1 Trials on phytosanitation

- The percentage of trees with fresh incidence reduced from second year after phytosanitation.
- Mean number of CSRB grubs encountered per infested tree reduced significantly in trials at NRCC.
- A maximum cost-benefit ratio of 1:1.8 was achievable due to phytosanitation in comparison to non-phytosanitation.

7.8.2.3.2 Post treatment prophylaxis

- Chlorpyrifos (0.2%) led to highest percentage of trees without reinfestation, followed by monocrotophos (0.2%) and lindane (0.2%) (Table 7.41).
- Treated trees in initial or moderate stages of attack showed highest recovery.

7.8.2.3.3 Kairomones and sex pheromones

- Unmated male beetles and virgin female beetles displayed maximum response to test samples viz., extracts and volatiles of healthy bark, fresh frass and exuded gum in n-hexane.
- Under trials on sex pheromones response by virgin female beetles was the highest to all body extracts (abdominal tip, thorax, base of elytra) followed by mated females.
- Maximum adults emerge only during a short period (February-May). Use of insect traps based on kairomones or pheromones during this emergence period can help in catching local pest population as well as predicting the initiation of pest attack.

Table 7.39: Major nutrients contributed by ORCB (kg/ha/year)

Centre	N	P	K
Puttur	30.6-33.7	3.01-3.27	5.17-5.77
Vengurle	16.66-17.4	1.7-1.73	3.59-4.19
Bhubaneswar	35.8-43.7	3.71-4.53	6.10-7.95
Vridhachalam	18.7-23.0	1.88-2.39	3.31-4.2

Table 7.40: Profitable intercrops with cashew at different centers

Centres	Profitable Intercrops	Cost of cultn.(Rs.)	Yield (t/ha)	Income (Rs.)	Profit (Rs.)
NRCC, Puttur	Turmeric	30,920	3.35	67,000	30,920
BCKKV, Vengurle	Cucumber	15,722	7.89	50,050	34,329
OUAT, Bhubaneswar	Pineapple	44,450	10.0	60,000	15,550
	Turmeric	20,050	4.8	33,740	13,690
RRS, Vridhachalam	Ground nut	13,250	1.95	33,592	20,842

Table 7.41: Recovery levels under trials on post treatment prophylaxis

Treatment	Cost of treatments/ tree (Rs)	% of treated trees without reinfestation				
		NRCC	OUAT	BCKV	KAU	KKV
Chlorpyriphos (0.2%)	5.62	96.45 a	83.50 b	55.10 a	97.00 a	89.29 a
Monocrotophos (0.2%)	5.42	78.57 b	87.70 a	50.00 b	86.00 b	77.50 c
Carbaryl (0.2%)	6.40	60.72 c	85.80 b	37.00 d	93.00 a	85.00 b
Lindane (0.2%)	5.14	70.00 b	-	-	86.00 a	-
<i>M. anisopliae</i> Spwan (250 g/tree)	7.83	25.72 d	65.50 d	11.10 e	62.00 b	85.72 b
Neem oil	8.34	28.57 d	80.50 c	42.60 c	76.00 c	73.52 c

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

8. EDUCATION AND TRAINING

- Training on “Vegetative Propagation of Cashew” was organized during 20-21, August 2003 in which 12 trainees sponsored by Development Departments representing Karnataka, Goa and Kerala were trained on softwood grafting technique and nursery management. Similar training was also organised for SHGs sponsored by SKDRDP, Puttur on 19.9.2003 in which 22 trainees have participated.
- Training programmes (two nos) on “Pruning and Top working in Cashew” were organized for staff of KCDC Ltd. during 7-8 October 2003 and 4-5 November 2003. A total of 60 trainees have participated.
- A special training programme was organized for the officials of development departments of North Eastern States during 17-21 November, 2003. A refresher course was organized for the officials of development departments representing five states during 21-23, January, 2004. A special training programmes was organized for the officials of DOH, Tamil Nadu during 16-21, February 2004. A total of 70 participants were trained on improved aspects of cashew cultivation out of the three training programmes.

9. LINKAGES / COLLABORATION

Name of the organizations	Type of collaboration
PDBC, Bangalore	EAG and GCMS studies
UAS, Bangalore	DNA finger printing
SKDRDP, Dharmasthala	Thematic campaigns, laying out demonstration plots, trainings and Annual Cashew Day
DCCD, Kochi	Laying out demonstration plots / farmers training
Department of Horticulture, Kumta	Seminar on improved cashew cultivation
Mangalore University Economics Association / Bharatiya Kissan Sanga, Puttur	Seminar/Exhibition

10. AICRP CENTRES

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7. Regional Agricultural Research Station, (Kerala Agricultural University), Pilicode 671 353, Kasaragod District, Kerala.
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8. Regional Fruit Research Station, (Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth), Vengurle 416 516, Sindhudurg District, Maharashtra
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9. Regional Research Station, (Tamil Nadu Agricultural University), Vridhachalam 606 001, Cuddalore District, Tamil Nadu.
Phone : 04143-260231, 260412

11. GENERAL INFORMATION

11.1 Research / Popular Publications

Bhat, M.G., Bhat, P.S., Nagaraja, K.V. and Nayak, M.G. 2004. Research Accomplishments of National Research Centre for Cashew, Puttur-574202, DK, Karnataka. Golden Jubilee (1953-2003) Souvenir. Agricultural Research Station (University of Agril. Sciences), Ullal, Mangalore, DK, 24-30.

Bhat, M.G., Nagaraja, K.V. Bhat, P.S. and Nayak, M.G. 2004. Advances in Production Technology for Cashew in India. Golden Jubilee (1953-2003) Souvenir. Agricultural Research Station (University of Agril. Sciences), Ullal, Mangalore, DK, 17-23.

Nagaraja, K.V. 2003. Preparation of spread from cashew kernel baby bits. *J. Food Sci. and Technol.* **40**(3): 337-339.

Sreekanth, P.D. and Bhaskara Rao, E.V.V. 2003. Model for forecasting yield in cashew. *The Cashew.* XVII(4): 23-31.

Sundararaju, D. 2002. Description of endoparasitism in nymphs and adults of *Helopeltis* spp. infesting Cashew. *J. Plantn. Crops.* **30**: 66-68.

Sundararaju, D. 2002. Life table studies of *Helopeltis antonii* Sign. (Heteroptera : Miridae) under field condition. *Insect Environment.* **8**: 55-57.

Venkattakumar, R and Bhat, P.S. 2003. Widening cashew growers perspective. *The Cashew.* XVII (2): 25-30.

Venkattakumar, R and Bhat, P.S. 2003. Technical Advice – A tool for effective transfer of cashew technology. *The Cashew.* XVII (3): 26-31.

Yadukumar, N. 2003. Strategies for improved productivity through efficient water management. *The Cashew.* XVII(3): 21-25.

Yadukumar, N., Bhat, P.S. and Bhat, M.G. 2003. Geru Belesiri – Labha and Galisiri (in Kannada) Vijaya Karnataka (Daily) July 2, 2003.

Yadukumar, N., Swamy, K.R.M. and Bhaskara Rao, E.V.V. 2003. Projection on economics of establishment and maintenance of cashew plantations under different plant densities. *The Cashew.* XVII(3): 6-16.

11.2 Papers presented in Symposia / Workshop / Seminar

Kumaran, P.M., Bhat, M.G., Ananda, K.S. and Arunachalam, V. 2004. Enhancement of Heterosis in Fruits and Plantation Crops. Paper presented in “National Symposium on Harnessing Heterosis in Crop Plants” held at Indian Institute of Vegetable Research, Varanasi during March 13-15, 2004 (Organized by Indian Society of Vegetable Science, IIVR and ICAR).

Faleiro, J.R., Ramesh, R., Sundararaju, D., Chander Rao, S. and Mani Chellappan. 2002. Insect pest and disease management of major field and horticultural crops – An overview of technologies developed in Goa. Extended Summaries. National Conference on Coastal Agrl. Research, ICAR Research Complex for Goa. pp.132-133.

Nayak, M.G. and Bhat, M.G. 2004. Biodiversity in cashew, its conservation and utilization in crop improvement. Paper presented in National Seminar on Horticulture for sustainable income and environmental protection held at SASRD, Nagaland University, Medziphima in Dimapur between 24-26th February 2004.

Nayak, M.G., Muralikrishna, H. and Bhat, M.G. 2003. Characterization and evaluation data of Cashew Gene Bank. Paper presented in the Brainstorming Session on “Database for the management of Genetic Resources of Horticultural Crops” (Session-IV) held at Bioinformatics Centre, CPCRI, Kasaragod, Kerala on June 19, 2003.

Nayak, M.G., Shirly R. Anil, Bhat, M.G. and Muralikrishna, H. 2003. Status and scope of Bioinformatics in characterization and evaluation of cashew germplasm. Paper presented in the “Workshop on Agricultural Bioinformatics” organized at Indian Institute of Spices Reseserach, Calicut, Kerala during October 29-30, 2003.

Shirly R. Anil and Thimmappaiah. 2003. *In vitro* conservation strategies for Anacardiaceae. In the Brainstorming session on “Database for the management of genetic resources of Horticultural Crops held at CPCRI, Kasaragod on 19.6.2003.

Sundararaju, D. 2002. Biotic stress on cashew – pests and diseases in cashew. Invited Lead Paper presented in 5th National Cashew Seminar, 12-13 April 2002. Vishakhapatnam conducted by DCCD, Kochi 682 011. pp.95-101.

11.3 Book / Chapters

Bhaskara Rao, E.V.V. Yadukumar, N. and Bhat, M.G. 2003. Agro-Ecological Regions and Varietal Classification of Cashew in Development Strategies. Indian Cashews issues and strategies. 2002. Edited by HP Singh, PP Balasubramanian and Venkatesh N Hubballi, Directorate of Cashewnut and Cocoa Development, Government of India, Ministry of Agriculture, Department of Agriculture and Cooperation, Kochi 682 011.

Yadukumar, N. 2003. Organic farming practices in cashew. Recent Advances in Organic farming technologies in Plantation Crops. Short course 2003. Edited by Dr. George V Thomas, Head Crop Production division and Course Director, Central Plantation Crops Research Institute, Kasaragod, Kerala, India.

11.4 Technical Reports / Bulletins / Compendia

All Indian Coordinated Research Project on Cashew. 2003. Annual Report 2002-03. NRC Cashew, Puttur, Karnataka.

National Research Centre for Cashew. 2003. Annual Report 2002-03, Puttur, Karnataka, 96 pp.

National Research Centre for Cashew. 2003. Cashew News, Newsletter. Vol.8 (1), Puttur, Karnataka. 8 pp.

National Research Centre for Cashew. 2003. Cashew News, Newsletter. Vol.8 (2), Puttur, Karnataka, 8 pp.

Swamy, K.R.M. and Nayak, M.G. 2003. Softwood grafting technique and nursery management in cashew. Revised Edition. NRCC Technical Bulletin No.6. (Publication assistance: Sreenath Dixit and R. Venkattakumar).

Venkattakumar, R., Yadukumar, N, Bhat, P.S. and Bhat, M.G. 2003. Cashew production technology (Revised). NRC-Cashew, Puttur, Technical Bulletin No.5. 36 pp.

11.5 Extension bulletins / pamphlets

Nayak, M.G. 2003. "Geru Gidagala Savaruvike" (Training and Pruning in cashew) (Kannada). NRCC folder No.9.

Nayak, M.G., Bhat, P.S. and Raviprasad, T.N. 2003. "Geru Gidagala Punaschetana" (Top working in cashew). (Kannada). NRCC folder No. 10. 6 pp.

Cashew cultivation practices. 2003. NRCC Handout No.1 Revised Edition. 6 pp.

Folder on Soil and water conservation in cashew. Revised edition. 4 pp.

12: LIST OF ONGOING RESEARCH PROJECTS

Project No.	Project Title	Project leader/associate
CROP IMPROVEMENT		
1.1	Collection, conservation, cataloguing and evaluation of cashew germplasm	MG Nayak MG Bhat PS Bhat
Ad-hoc	Network programme on hybridisation in cashew.	MG Bhat
1.2	Varietal Improvement of Cashew	MG Bhat MG Nayak
1.5	Micropropagation studies for clonal root stocks, somatic embryogenesis and rooting in cashew.	Shirly R Anil Thimmappaiah
1.6	Molecular characterization of cashew using RAPD and isozyme markers	Thimmappaiah Shirly R Anil
CROP MANAGEMENT		
2.2	Planting systems and spacings trials in cashew	N Yadukumar
2.3	Canopy management studies in cashew	MG Nayak N Yadukumar
2.8	Efficacy of soil and water conservation with organic and inorganic manuring in cashew garden grown in slope areas	N Yadukumar R Rejani
Ad-hoc	Influence of fertigation on yield and quality of cashew.	N Yadukumar
NATP	Developing integrated production packages for enhancing productivity of cashew	N Yadukumar TN Raviprasad KV Nagaraja, SL Nandan, C.H. Yajnes, Gettha
CROP PROTECTION		
3.8	Integrated pest management of cashew stem and root borer (CSRB) – Phase-II	TN Raviprasad PS Bhat
3.9	Bioecology and management of lepidopteran flower and fruit pests of cashew.	D Sundararaju
3.10	Foraging behaviour of pollinators of cashew.	D Sundararaju
3.6	Studies on determination of insecticide residues in cashew kernels.	PS Bhat TN Raviprasad
3.7	Studies on pheromones of tea mosquito bug <i>Helopeltis antonii</i> S.	PS Bhat TN Raviprasad
POST HARVEST TECHNOLOGY		
4.6	Standardization of protocol for cashew apple utilization	KV Nagaraja
4.7	Developing economically viable on-farm cashew nut processing	D Balasubramanian
4.8	Mineral composition of cashew kernel, testa, apple, pomace of released varieties.	KV Nagaraja S Bhuvaneswari (upto 26.6.2003)
5. TRANSFER OF TECHNOLOGY		
5.1	Research cum demonstration plots	R. Venkattakumar P.S. Bhat M.G. Nayak
5.2	Impact of transfer of technology in cashew cultivation	R Venkattakumar TN Raviprasad MG Nayak
6.COMPUTER APPLICATION		
6.1	Computerized information management system for cashew	PD Sreekanth

13. IMPORTANT MEETINGS AND SIGNIFICANT DECISIONS

13.1 Research Advisory Committee

- | | | |
|----|---|------------------|
| 1. | Dr. M.V.Rao, Former Special Director General, Indian Council of Agricultural Research, Plot No.4, BHEL Colony, Akbar Road, Bowanpally, Secunderabad – 500 009 | Chairman |
| 2. | Dr. A.N. Maurya, Former Director, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh- 221 005 | Member |
| 3. | Dr. V.C. Patil, Professor and Head, Department of Agronomy, University of Agricultural Sciences, Dharwad, Karnataka-580 005 | Member |
| 4. | Dr. M. Udaya Kumar, Professor and Head, Department of Crop Physiology, University of Agricultural Sciences, Dharwad, Karnataka-580 005 | Member |
| 5. | Dr. Amerika Singh, Director, NRC for Integrated Pest Management, LBS Building, Pusa Campus, New Delhi – 110 012 | Member |
| 6. | Dr. S.N. Pandey, Assistant Director General (PC), Indian Council of Agricultural Research, Krishi Bhavan, New Delhi – 110 001 | Member |
| 7. | Dr. M.G. Bhat, Acting Director, NRC-Cashew, Puttur, Karnataka-574 202 | Member |
| 8. | Dr. K.V. Nagaraja, Principal Scientist (Biochemistry), NRC-Cashew, Puttur, Karnataka – 574 202 | Member-Secretary |

13.2 Institute Management Committee

- | | | |
|-----|--|------------------|
| 1. | Dr. M.G. Bhat, Acting Director, NRC-Cashew, Puttur | Chairman |
| 2. | Dr. S.N. Pandey, Asst. Director General (Hort and PC), ICAR, Krishi Bhavan, New Delhi 110 001 | Member |
| 3. | Dr. D. Sundarraju, Principal Scientist (Ent), NRC for Cashew, Puttur | Member |
| 4. | Dr. B.M.C. Reddy, Project Coordinator (Tropical Fruits), Indian Institute of Horticulture Research, Bangalore | Member |
| 5. | Dr. K.R. Jayaram, Joint Director of Horticulture (PC), Department of Horticulture, Bangalore – 560 004 | Member |
| 6. | Sri. G.K. Naidu, Kacharvedu Village, Alapakam Post, Nintramandal, Chittor District, Andhra Pradesh | Member |
| 7. | Dr. P. Sadashiva Rao, Joint Director of Horticulture, Department of Horticulture (Agency), O/O Commissioner of Horticulture, Hyderabad, Andhra Pradesh | Member |
| 8. | Dr. T.R. Guruprasad, Associate Professor and Head, Agricultural Research Station, Ullal, Dakshina Kannada, Mangalore, Karnataka | Member |
| 9. | Dr. M.G. Nayak, Senior Scientist (Hort), NRC Cashew, Puttur | Member |
| 10. | Sri. K. Sanjeeva, Assistant Administrative Officer, NRC Cashew, Puttur | Member-Secretary |

The committee met twice on 7-6-2003 and 25-3-2004 and reviewed the progress of research project and ad-hoc projects. The equipments to be purchased and the works to be undertaken during X Plan period were finalized during the meetings.

13.3 Staff Research Council Meeting

The sixteenth Staff Research Council Meeting was held at NRCC during 29-30 May 2003 to review the ongoing projects of the centre. Dr. P.M. Kumaran (Crop Improvement), Dr. V. Rajagopal (Crop Management), Dr. Mariamma Daniel (Crop Protection) and Dr.K.P.Gopalakrishna Rao (Post Harvest Technology) and Dr. V.S. Korikantimath (Transfer of Technology and supportive programmes) chaired the technical sessions. Dr. M.G. Bhat, Acting Director highlighted the research and development activities of NRCC and the challenges ahead in production, processing and marketing of cashew. Dr. V. Rajagopal, Director, CPCRI, Kasaragod, released publication “Research Highlights 2002-03” of the centre. During the meeting it was suggested to initiate studies on medicinal values of cashew and its products in collaboration with Central Institute for Medicinal and Aromatic Plants (CIMAP), Lucknow and National Institute for Animal Nutrition, Bangalore. Seven new projects were also approved for implementation.

13.4 Institute Joint Council (IJC)

Official Side	
Dr. M.G. Bhat	Chairman
Dr. N. Yadukumar	Member
Dr. M.G. Nayak	Member
Sri. K.Sanjeeva	Member
Sri. A.K. Shabaraya	Member
Sri. P.D. Sreekanth	Secretary
Staff Side	
Sri. K. Umanath	Member (CJSC)
Sri. K.R. Padmanabhan Nair	Member-Secretary
Smt. B. Jayashree	Member
Sri. K. Umashankar	Member
Sri. K. Narayana	Member
Sri. V. Sundara	Member

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

13.5 RAJBASHA (Enclosed)

14. PARTICIPATION IN SYMPOSIA / CONFERENCES / SEMINARS / MEETINGS

Thimmappaiah MG Nayak Shirly R Anil	Brain storming session on “Database for the Management of Genetic Resources of Horticultural Crops” at CPCRI, Kasaragod.	19 June 2003
Thimmappaiah	Discussion meeting on Molecular Breeding at NBPGR, New Delhi	4 September 2003
MG Nayak PD Sreekanth	National workshop on Bioinformatics held at IISR, Calicut	29-30 October 2003
Thimmappaiah	NATP sponsored training on “Techniques in gene cloning, sequencing and plant transformation” at Indian Institute of Horticultural Research, Bangalore.	17-29 November 2003
PS Bhat	Seminar on plant protection in cashew organized at Mundoor by SKDRDP, Dharmasthala.	30 December 2003
PS Bhat	Workshop on environment at St. Philomina College, Puttur organized by district science and technology committee.	6 January 2004
MG Bhat KV Nagaraja TN Raviprasad	Golden Jubilee Celebrations of Agricultural Research Station, (University of Agril. Sciences, Bangalore), Ullal, Mangalore and Cashew Field Day.	4 February 2004
N Yadukumar	International conference on organic food 2004 held at ICAR Research Complex, Barapani, Meghalaya.	15-17 February 2004
R Venkattakumar	Networking planning workshop on “Total Factor Productivity” for field and horticulture crops in India” at New Delhi organized by DDG (Hort)	17 February 2004
MG Nayak	National Seminar on Horticulture for sustainable income and environmental protection held at SASRD, Nagaland University, Medziphima, Dimapur, Nagaland state	27-29 February 2004
N Yadukumar	National conference for organic farming for sustainable production, NASC complex, Devprakash Shastri Marg, Pusa, New Delhi – 110 012	23-25 March 2004

15. FARMERS DAY/KRISHIMELA/EXHIBITION/CAMPAIGNS

N Yadukumar MG Nayak R Venkattakumar	Campaigns on “Pruning, High Density Planting and Soil and Water Conservation measures in Cashew” at Kavu and Keyyur Villages	2 May 2003 18 June 2003
MG Bhat N Yadukumar PS Bhat MG Nayak TN Raviprasad R Venkattakumar	Campaign on “Cashew cultivation” at Panaje village	21 October 2003
N Yadukumar PS Bhat TN Raviprasad R Venkattakumar	Campaign on “Plant protection”	8 December 2003

R KV Nagaraja N Yadukumar PS Bhat MG Nayak R Venkattakumar	Seminar on “Improved cashew cultivation” at Kumta.	29 January 2004
All scientists	Cashew Field Day at Experimental Station, Shantigodu	19 March 2004

16. DELEGATION / TRAINING

PD Sreekanth	Summer school on “Forecasting Techniques in Agriculture”. IASRI, New Delhi	9-29 July 2003.
R Venkattakumar	Short course on “Capacity building of extension scientists to meet out the WTO challenges for sustainable agriculture”. DEE, ANGARAU, Hyderabad	22-31 July 2003
MG Nayak	“Computer training course on MS office, SPSS” at IASRI, New Delhi.	16 July – 5 August 2003
PS Bhat Shirly R Anil	Winter school on “Spatial and non-spatial databases on agricultural research systems” at IARI, New Delhi – 110 012	9-29 September 2003
Shirly R Anil	Training programme on “Bioinformatics resources and databases” at CPCRI, Kasaragod.	5-7 November 2003
KV Nagaraja	“Computer training course on MS office, SPSS” at IASRI, New Delhi.	27 November - 17 December 2003

17. DISTINGUISHED VISITORS

Dr. D.M. Hegde, Project Director, Directorate of Oilseed Research, Rajendranagar, Hyderabad	13-6-2003
Dr. N.D. Jambhale, Director of Research, Dr Balasaheb Saawnt Konkan Krishi Vidyapeeth, Dapoli, Maharashtra	28-10-2003
Dr. N.T. Yaduraju, Director, NRS WS, Jabalpur, Madhya Pradesh	24-11-2003

18. DEPUTATION ABROAD

MG Bhat	<p>Visited Vietnam as a member of multidisciplinary team under Indo-Vietnam Workplan for 2002-03. The team visited following institutes / departments:</p> <ul style="list-style-type: none"> - Research Institute for Fruits and Vegetables (RIFAV), Trauquy, Gialam, Hanoi. - Vietnam Agricultural Sciences Institute (VASI), Thanh Tri, Hanoi. - Fruit and Forestry Department of Lao Cai Provinces Peoples Community, Lao Cai - VEGETECO Farm, Sapa - Trai Glong Hoa, Sapa - Horticultural Farmer’s Plot at Sapa - Agricultural and Vegetable Commune, Van Noi, Near Hanoi - South East Asia Agricultural Exhibition Fair 2003, Hanoi 	3-8 November 2003
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19. PERSONNEL

Managerial

Acting Director

Dr. M.G. Bhat (w.e.f. 1-4-2003)

Scientific

Discipline	Scientist	Scientist (Sr.Scale)	Sr.Scientist	Pr.Scientist	Total (Incl. Vacant Posts)
Agricultural Engg. (ASPE)	D. Balasubramanian* S Bhuvanewari (upto 26.6.2003)	--	--	--	1
Agricultural Entomology	--	--	P.S. Bhat T.N.Raviprasad	D.Sundararaju w.e.f 27.7.1999	3
Agril.Extension	R. Venkattakumar	--	--	--	1
Biochemistry (Pl.Sci.)	--	--	--	KV Nagaraja	1
Biotechnology	--	--	--	Thimmappaiah (Gen.& Cyto.)	1
Computer Application	PD.Sreekanth	--	--	--	1
Genetics and Cytogenetics	--	Shirly R Anil	--	--	1
Horticulture	Vacant**	--	MG Nayak (Hort.)	Vacant M.G. Bhat (Pr. Br.)	4 (2)
Plant Physiology	Vacant	--	--	--	1 (1)
Soil Science	--	--	--	N Yadukumar (Agr.)	1
Soil and Water cons. Engg.	R. Rejani	--	--	--	1
Total	6 (2)	1	3	6 (1)	16 (3)

* On study leave for Ph.D. at TNAU, Coimbatore

Figures in the parantheses indicate no. of vacant osts.

** Mr. D. Balasubramanian was adjusted temporarily against the post of scientist (Hort.) till 26.6.2003.

TECHNICAL

Sri.K.Muralikrishna,	Farm Superintendent (T6)
Sri. P. Adbulla,	Farm Superintendent (T6)
Sri.H.Muralikrishna,	Tech. Inf. Officer (T-6) (Upto 30-3-2004)
Sri.A.Padmanabha Hebbar,	Tech. Officer (Elec.) (T-5)
Sri.R.Arulmony,	Tech. Officer (lib.) (T-5)
Sri.Prakash G Bhat,	Tech. Officer (T-5)
Sri.N.Manikandan	Technical Officer (T-5)
Sri. R. Muthuraju	Technical Officer (Computer) (T-5)
Sri. K. Seetharama	Technical Officer (T-5) (Farm)

Sri.Lakshmpathi, Sri.R.Lakshmisha, Sri.V.Ramesh Babu (T-4); Sri.KR.Padmanabhan Nair, A.Poovappa Gowda, Sri. B. Prabhakara (w.e.f. 18-2-2004) (T-3); Ravishankar Prasad (T-2), K.Babu Poojary, Sri. Bejmi Veigus, Sri.KK.Madhavan (T-2); Sri. K.Umanath (T-1)

ADMINISTRATIVE

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

Ms. B. Jayashree, Sri. O.G.Varghese (Stenographers); Sri.K.M.Lingaraju (Assistant); Ms.M.Ratna Ranjani, Ms.Winne Lobo, Sri.Rosario Mascarenhas, Ms. Leela (Sr.Clerks); Sri.Uma Shankar (Jr-Clerk); Sri.K.Balappa Gowda (Gestetner Operator)

20. MISCELLANEOUS

20.1 Graft production

- During 2003-04 a total of 96,801 cashew grafts (47,592 through ICAR Revolving Fund Scheme and 49,209 through DCCD Regional Nursery Scheme) were distributed to Development Departments, Non-Governmental Organizations and Farmers.
- Details about variety-wise availability of cashew planting material (about 19 lakh grafts) in various private and Government Regional Nurseries (15 nos.) representing Karnataka, Kerala, Tamil Nadu, Maharashtra and Goa were collected and put into NRCC website to keep the farmers informed about the availability of planting material.
- A total of 815 visitors viz., farmers (335), students (440), extension personnel (23) and researchers (15) were explained about the activities of NRCC and cashew cultivation practices.
- Technical advice was provided to the queries (30) of various clients who are related to cashew on the aspects viz., Crop Improvement (6), Crop Management (5), Crop Protection (1), Post-Harvest Technology (4) and Transfer of Technology (14).
- Six exhibitions (with panels, specimens etc) on various aspects of cashew cultivation were organized during thematic campaigns, cashew day and seminars.

20.2 Weather data (2003-2004)

Month	Temperature (°C)		Humidity (%)		Rainy days	Rain (mm)	Sunshine hours	Evaporation
	Max	Min	FN	AN				
April '03	36.5	24.9	91	50	7	47.3	7.1	5.4
May	36.1	25.3	88	51	1	13.0	7.2	6.0
June	30.5	23.2	95	78	19	1056.3	2.5	3.4
July	29.1	23.1	96	84	31	703.3	0.5	2.2
August	29.3	23.1	97	82	23	579.4	0.7	2.6
September	30.8	22.6	95	71	10	122.7	4.5	3.5
October	32.2	23.2	95	68	13	263.6	5.0	2.9
November	34.3	21.1	88	46	1	5.9	7.7	3.9
December	33.9	17.0	89	35	0	0.0	9.2	4.0
January '04	33.8	18.5	93	39	0	0.0	8.3	4.0
February	36.1	19.7	94	36	0	0.0	8.6	4.4
March	36.9	23.4	91	45	2	14.0	6.4	5.1