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

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National Research Centre for Cashew
Annual Report 2005-'06, Puttur, Karnataka

Published by

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भूमिका

PREFACE

I am happy to present the Annual Report 2005-06 of National Research Centre for Cashew, Puttur covering the achievements of the centre for the period from April 2005 to March 2006. The scientists of the centre have undertaken the research projects in the areas of Crop Improvement, Crop Management , Crop Protection, Post-Harvest Technology , Transfer of Technology and Computer Application as per the approved technical programme,.

In National Cashew Field Gene Bank (NCFGB), six more accessions were planted during the year, bringing the total accessions conserved so far to 500. Hybrids H 1250 and H 2452 were promising with cumulative yields of 42.12 and 27.30 kg/tree for 11 and seven harvests respectively. Efforts were continued for molecular characterization of cashew and selective primers of RAPD (10 nos) were used for characterizing released / elite varieties. In the third fruiting season after limb pruning, the yield was significantly superior over the unpruned trees. Soil and water conservation measures such as modified crescent bund and staggered trenches with coconut husk burial were helpful in reducing run off and soil loss. Post extraction prophylaxis (PEP) and phytosanitation were helpful in the reduction of cashew stem and root borer (CSRB) infestation in different plots. The residue of λ-cyhalothrin was not detected in the kernels of the samples collected from the treated plots. The centre has initiated studies on nutraceuticals from cashew apples for the preparation healthy and speciality foods. The centre continued its collaboration with DCCD, Kochi, SKDRDP, Dharmasthala , All India Radio, Mangalore and E-TV, Hyderabad and Development Departments for technology transfer activities.

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 : 30th August 2006

(M. Gopalakrishna Bhat)
Director

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...सारांश

EXECUTIVE SUMMARY

During the year, a total of 21 projects including two ad-hoc projects were in operation. Three diverse types have been identified for collection from Karnataka and Andhra Pradesh. Six collections made from Karnataka during 2004-05 were planted in National Cashew Field Gene Bank (NCFGB) bringing the total accessions conserved so far to 500. A hybrid H 1250 was found promising under medium nut category with annual yield of 4.09 kg /tree in 11th harvest and cumulative yield of 42.12 kg / tree for 11 harvests. Another hybrid H 2452 with annual yield of 5.8 kg/tree in seventh harvest and cumulative yield of 27.30 kg/tree from seven harvests was also found promising. Somatic embryos of cashew varieties Kanaka and BPP 6 were successfully germinated in media containing NAA and GA_3. Selective primers of RAPD (10 nos) were used for characterizing 42 released / elite varieties of cashew. Isozyme extraction and staining protocol of 14 enzyme systems were standardized. A total of 13 enzymes showed polymorphism in their isozymes and one was homomorphic.

In the third fruiting season after limb pruning, the trees behaved on par with unpruned trees in flowering and fruiting time and the yield was significantly superior over the unpruned trees. Soil and water conservation measure viz., modified crescent bund and staggered trenches with coconut husk burial conserved maximum soil moisture with minimum run off and soil loss compared to control. Increased nut yield was also recorded in these treatments.

In post extraction prophylaxis (PEP) trials with chlorpyriphos (0.2 and 0.4 %) against cashew stem and root borer (CSRB), there was no reinfestation of the pest for a minimum period of 70 days. In phytosanitation trials, the reduction in the infestation of CSRB ranged between 21.45 to 60.98 % in different plots compared to the previous years. The apple and nut borer *Thylacoptila paurosema* was the major flower fruit pest in both west (coastal Karnataka) and east coasts (Tamil Nadu). The larval parasitism ranged from 32.8 to 46.2 % on this pest. The residues of λ-cyhalothrin was not detected in the kernels of the samples collected from the plots treated with this insecticide.

Pectin extracted from cashew apple powder, is low methoxyl pectin (5 to 6.3%).The pectin ash is rich in Na, K, Ca and Mg. Sun dried cashew apple powder of different varieties was analyzed for its composition and the variability noticed among different varieties. Blends of cashew apple powder (autoclaved and dried) with cereals (rice, ragi and wheat flour) at

concentration ranging between 5 and 20 % were prepared and antioxidant activities in methanol extract was determined.

A total of 15 model clonal cashew orchards were laid out at farmers plots during the year. A thematic campaign on "Soil and water conservation measure and high density planting in cashew " was organized at Kavdichar village in Puttur taluk in collaboration with Sri Kreshtra Dhramasthala Rural Development Project (SKDRDP) , Puttur Several training programmes viz.., "Vegetative propagation of cashew", " Pruning, topworking and composting of cashew biomass", "Composting of cashew biomass" and "Cashew production technology" were arranged at NRCC, Puttur in which around 80 official and members of self Help Group participated. Annual Cashew Day was organized on 14th March 2006 with a theme " Increasing yield of cashew orchards" wherein about 250 farmers participated. A training programme on "Cashew apple utilization" was also organized in collaboration SKDRDP, Puttur in which 45 farmwomen participated.

I feel extremely happy to present summary of results of the on – going research projects of the centre for the year 2005-06.

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 had 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 under operation in eight centres and a sub centre distributed in major cashew growing areas of the country.

MANDATE

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

ORGANIZATIONAL SET UP AND INFRASTRUCTURE

- National Research Centre for Cashew is located at Puttur, Dakshina Kannada, Karnataka. The main campus is situated 5 KM away from Puttur town (at Kemminje: 12.45° N latitude, 75.4° E longitude and 90m above MSL).

- The main campus has an area of 68 ha with field experiments and Laboratory-cum-Administrative Block. Experimental Station at Shantigodu, which also forms part of the Research Centre is 13 KM away from the main campus and has an area of 80 ha.

- The centre has got well-established library in the field of cashew research. The library is serving as an information centre on all aspects of cashew research and development in the country. The CD database viz., CABHORT, CABPEST, AGRICOLA and AGRIS, SOIL CD, CROP CD, PLANTGENE CD and TROPAG CD are also available in the library. The library also has library automation software and bar- coding facility.

- The centre has got local area network of computers with Internet connections. The centre has got its own website which is updated at monthly intervals.

- The headquarters of AICRP on Cashew is located at NRC Cashew, Puttur. It has eight Coordinating Centres and a Sub-Centre located in Karnataka, Kerala and Maharashtra in West Caost, Andhra Pradesh, Orissa, Tamil Nadu and West Bengal in the East Coast and in Chattisgarh.

SIGNIFICANT ACHIEVEMENTS

- It has the largest germplasm collection of cashew in the country (National Cashew Field Gene Bank) with 500 accessions. 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.

- During 2006, another high yielding variety namely “Bhaskara” has been released to coastal region of Karnataka.

- In micropropagation, regeneration of cashew from the seedling explants (nodal cultures) has been standardized.

- Micrografting technique for *in vitro* multiplication of cashew has been standardized and cashew plants raised by micro grafting have been potted.

- Protocols have been standardized for characterization of released varieties and cashew germplasm accessions using RAPD/IISR markers and isozymes.

- The centre has also demonstrated the advantage of growing intercrops like pineapple 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 P_2O_5 and 67.8 kg K_2O/ha.

- Individual tree terracing with crescent bunding is the best soil and water conservation measure in slopy 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 beign commercially utilized for large scale production of planting material in cashew in the country.

- Rearing technique for cashew stem and root borer (CSRB) on host bark has been standardized.

- Results from trial on phytosanitation confirmed the positive effect of phytosanitation in reducing the level of CSRB incidence in a given location.

- Chlorpyriphos (0.2-0.6%) was an effective chemical for post- treatment prophylaxis measures against CSRB.

- Studies have been taken up for the identification of kairomones of CSRB. Volatiles and extracts in hexane from both healthy bark and frass on testing by EAG elicited response from adult female beetles of CSRB.

- Laboratory rearing technique for tea mosquito bug (TMB) has been standardized. Among the new insecticides evaluated against the pest, 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 testa and cashew apple pomace of released varieties has been analysed for mineral composition and varietal variation noticed. Mineral composition of cashew apple pomace could be improved by blending with defatted flours of either cashew or almond.

- Cashew apple powder lipids are rich in unsaturated fatty acids and the major fatty acids are palmitoleic and oleic acids.

- Impact of transfer of technology (TOT) was assessed and strategies were suggested for refining the TOT efforts.

- Yield forecasting model for predicting cashew yield was developed and refined.

- The centre has established very good linkage with farmers and officials of State Departments and Development Agencies related to cashew.

Budget (2005-'06)

(Rs. In lakhs)

Plan	Non-Plan	External	Total
92.08	151.76	5.31	249.15

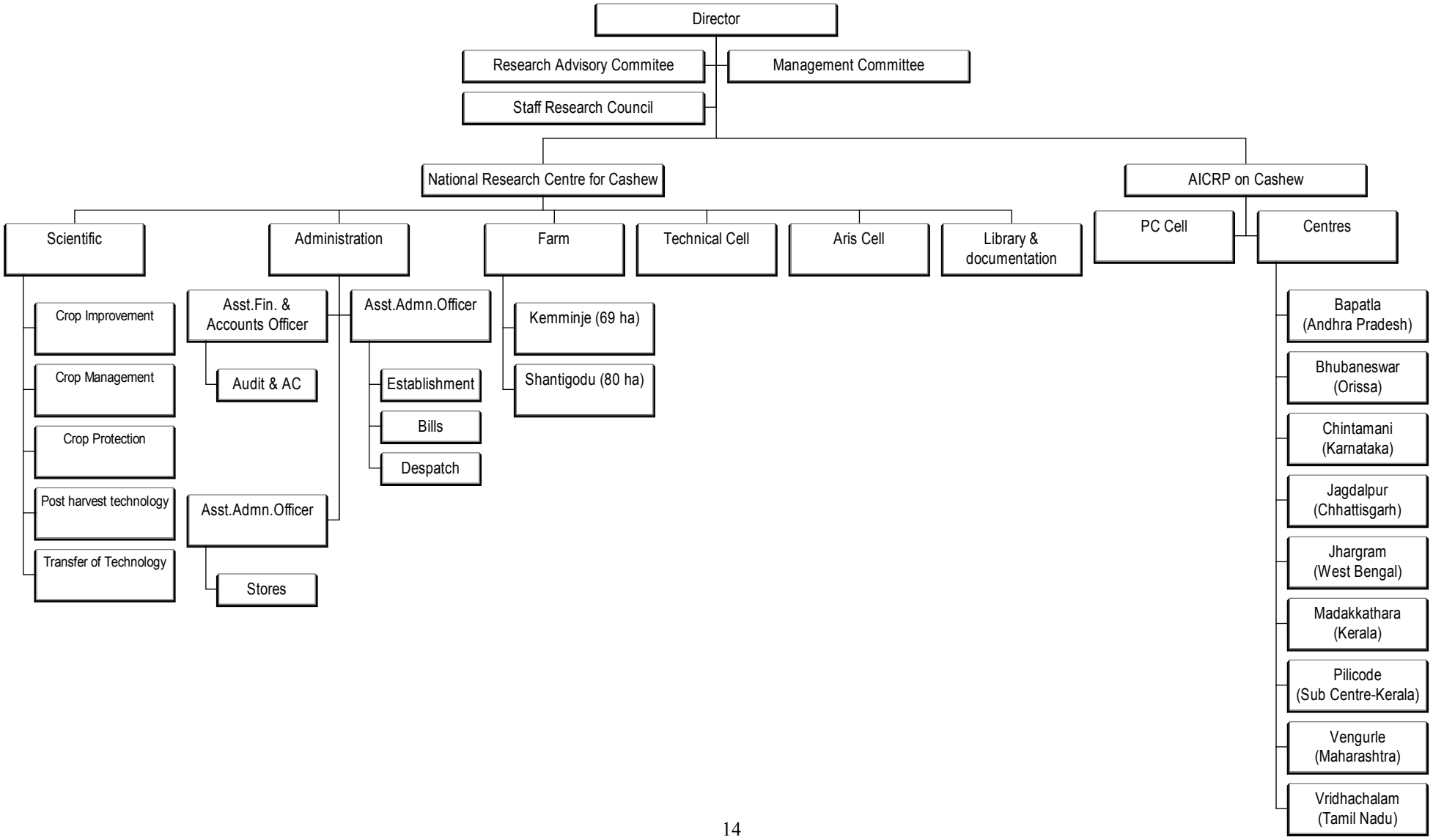
STAFF POSITION AS ON 31.3.2006

Category	NON PLAN			PLAN			TOTAL		
	Sanct-ioned	Filled	Vacant	Sanct-ioned	Filled	Vacant	No. of Posts	No. filled No.	Vacant
Director (RMP)	1	1	-	-	-	-	1	1	-
Scientific	18	11	7	-	-	-	18	11	7
Technical	19	19	-	4	-	4	23	19	4
Administrative	14	14	-	1	-	1	15	14	1
Supporting	41	41	-	-	-	-	41	41	-
Canteen	1	1	-	-	-	-	1	1	-
Total	**94**	**87**	**7**	**5**	**-**	**5**	**99**	**87**	**12**

TOTAL MANPOWER

	Sanctioned	Filled	Vacant
Non Plan	94	87	7
Plan	5	-	5
Total	**99**	**87**	**12**

ORGANISATIONAL SETUP OF NRC-CASHEW



RESEARCH ACHIEVEMENTS

1. CROP IMPROVEMENT

1.1 Genetic resources of cashew

1.1.1 Germplasm collection

During the flowering and fruiting season of 2005-06, selected locations in Karnataka and Andhra Pradesh were surveyed and two bold nut types with high yield in Devarakolli of Coorg district, and one bold (9 g) and bunch bearing type with high yield in Dwaraka Thirumala of Rayalkunta village in West Godavari district, were identified for collection.

1.1.2 Germplasm conservation

Six collections made during 2004-05 were planted in NCFGB (6 plants /accession) at a spacing of 6 M x 6M for evaluation and conservation brining the total number of germplasm accessions conserved to 500 (Table 1.1).

A new Germplasm Conservation Block has been established with the 250 cashew accessions which have already been evaluated. In the Conservation Block four plants / accessions were planted at a closer spacing of 4M x 4M. Canopy of the plants will be contained within the allocated space by yearly pruning and shaping the plants.

Bold nut type identified at Dwaraka Thirumala

1.2 Varietal improvement of cashew

1.2.1 Evaluation of hybrids/selfs

Two promising hybrids, namely, H-46 (BPP-6 x A 18/4) and H 32/4 (BPP-5 x VRI-1) are under evaluation at Karnataka Cashew Development Corporation (KCDC), Puttur Division (planted in1999). The hybrid H 32/4 is also under testing in fields of some selected farmers (planted in 1999 and 2001).

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 (19.92 kg/tree and 19.27 kg/tree, respectively for 7 harvests) and annual yield (3.11 and 3.39 kg/tree respectively) compared to control VRI 2 (cumulative yield of 11.97 kg/tree and annual yield of 2.65 kg/tree) in a replicated trial.

A hybrid H 1250 (VRI-2 x VTH 40/1) was found promising under medium nut size category with an annual yield of 4.90 kg/tree in 11th harvest and cumulative yield of 42.12 kg/tree for 11 harvests. In another trial, a hybrid, namely, H 2452 (BLA 139-1 x VTH 711/4) with an annual yield of 5.80 kg/tree in 7th harvest and cumulative yield of 27.30 kg/tree from seven harvests was found promising .

Hybrids of several cross combinations were evaluated in hybrid graft trial at Shantigodu campus and a few hybrids appear to be promising in second harvest for yield and nut size. They are hybrids H-66, H-68 and H-43 (all of cross combination NRCC Sel-2 x Bhutnath-II) and hybrids H-125 and H-126 (both NRCC Sel-2 x Bhedasi). All these hybrids had cumulative yield of above 6 kg/tree for 2 harvests and nut weight more than 10 g.

A precocious dwarf and compact type KGN-1 from Madakkathara (Thrissur) Centre of AICRP-Cashew planted at 4m x 4m spacing in August 2002 was evaluated along with NRCC Sel-2 (control) for plant growth characters. The growth of KGN-1 was relatively less with respect to plant height, stem girth and mean canopy spread compared to NRCC Sel-2 (control) both at 3½ years of age. Internodal length of KGN-1, however, was slightly more compared to control (NRCC Sel-2) (Table 1.2).

1.3 Micropropagation

1.3.1 Micro propagation of rootstocks and elite lines

In vitro shoot-cultures were established from shoot explants of five elite varieties (Ullal-3, V-4, VRI-3, Sel-2 and Bhaskara) and three root-stock varieties (H-4-7, Brazil dwarf, Taliparamba) on hormone free half-MS medium. Contamination varied from 0-88.9%, bud break from 10 – 85.7% and shoot development from 0 – 27.3%. Shoot explants of Ullal-3 and Ullal-4 had maximum bud break (>60%). Treatments like covering of shoots with black polythene sheets, dipping of shoot segments before inoculation in 0.1% PVP or in hormone solution (BAP and GA_3 100 ppm conc.) had no significant effect on bud break. Explants on media (solid and liquid) containing BAP at different levels (5, 10, 15, 20, 25 µM/l) with 5 µM GA_3 and 1 µM IBA and hormone free media (control) also showed no improvement in response.Rooting attempted by culturing long shoots on half-MS medium containing IAA, IBA and salicylic acid and also pulsing shoots in IBA (5 mM) and culturing in hormone free media didn't evince any response for rooting. Immature embryos excised from 2-3 week old nuts were successfully germinated in light on both semi-solid and liquid MS medium containing NAA and GA_3. More than 80% germination was observed on media containing NAA alone.

1.3.2 Induction of Somatic embryogenesis

Nucellus cultures were initiated in bisected ovules of five varieties on media (MS, RBM) containing 2, 4-D alone and in combination with BAP or spermidine and or NAA in10 combinations. Maximum calli induction and growth were observed in varieties Kanaka and BPP-6. Nucellar Calli of varieties Kanaka and Bhaskara showed embryogenesis on transfer to hormone free media and incubated in light. Somatic embryos were matured on ABA medium and multiplied on hormone free Raj Bhansali medium. Somatic embryos of varieties Kanaka and BPP-6 were successfully germinated on media containing NAA and GA_3.

1.3.3 Evaluation of micropropagated plants in field

Growth observations recorded (girth, plant height and lateral spread) in replicated trial planted with two varieties (H4-7, VRI-II) with micropropagated and grafted plants showed significant difference among the treatments with significance observed only for varieties and variety x planting material interaction. In the observational trial

planted with variable number of micropropagated plants, H-4-7 was more vigorous and dwarf was less vigorous by almost 50% in plant height and lateral spread. The yield per plant was also not significant between the two varieties (H4-7 and VRI-2) planted in replicated trial. Some plants in observational trial, however, showed good performance in yield.

1.4 Molecular characterization

1.4.1 Molecular characterization of cashew

DNA was extracted from young cashew leaves of 150 germplasm accessions and 10 micro propagated plants using liquid nitrogen. PCR protocols for RAPD, ISSR and SSR markers were standardized. A total of 80 random primers from M/s Operon Technologies, USA were screened for RAPD polymorphism and polymorphism (7.1 to 75%) was found in 48 primers .Similarly seven ISSR primers were screened and two were found polymorphic.

Using 11 selected random primers (RAPD) and Isozyme pattern of six enzymes, 10 diverse collections of cashew namely *Anacardium pumilum*, *A. microcarpum, A. orthonianum,* four varieties of cultivated species *A. occidentale* and three interspecific hybrid plants were characterized and the cluster analysis indicated that *Anacardium pumilum* as most unique and divergent . Similarly 10 selective primers of RAPD were used for characterizing 42 released / elite varieties of cashew. Isozyme extraction and staining protocols for 14 enzyme systems were standardized.A total of 13 enzymes showed polymorphism in their Isozymes and one was homomorphic.

Table 1.1: Germplasm holding in NCFGB, Puttur

Source of collection	Number of accessions in NCFGB
Andhra Pradesh	102
Assam	3
Goa	45
Karnataka	120 +6*
Kerala	70
Maharashtra	45
Meghalaya	7
Orissa	21
Tamil Nadu	42
Tripura	3
West Bengal	14
Exotic	22
Total	500

* Planted during 2005

Table1.2: Evaluation of performance of compact and dwarf genotype KGN-1 for plant growth characters in comparison to NRCC Sel-2 variety (control) at 3½ years age

Characters	KGN-1	NRCC Sel-2 (Check variety)
Plant height (m)	3.23	3.42
Stem girth (cm)	31.52	37.30
Mean canopy spread (m)	3.32	3.84
Internodal length (cm)	2.49	2.22

2. CROP MANAGEMENT

2.1 Fertilizer application and pruning in high-density plantation

This experiment was taken up to study the nutrient requirement/unit area for three different plant densities. The experiment was laid out in 2001 with three plant densities viz., 200 (S1), 416 (S2) and 500 (S3) plants/ha as main plot treatments and three fertilizer doses viz., 75 kg N, 25 kg each of P_20_5 and K_20 (M1), 150 kg N, 50 kg each of P_20_5 and K_20 (M2), 225 kg N, 75 kg each of P_20_5 and K_20/ha (M3) as sub plot treatments.

2.1.1 Ground coverage by the tree canopy

Ground coverage by the tree canopy in the high tree density plots was significantly more (31.62 and 42.18 % of the given area) than in normal tree density plot (21.09 %). Among the subplots (manurial doses) it increased significantly as fertilizer level increased from M1 to M3. Interaction effect of density and fertilizer levels showed increased trend in combination of high tree density and highest level of fertilizers (S2M3 and S3M3 significantly superior to rest of the combinations). Similarly the combinations S2M2 and S3M2 are significantly superior to all the three densities with the lowest fertilizer level and combination of the lowest tree density with medium and higher levels of fertilizer (S1M2 and S1M3)

The yield in the high tree density plot (416 and 500trees/ha) was significantly more (260 and 320 kg/ha) than in normal tree density plot (138 kg/ha). Among the subplots (manurial doses) the yield increased significantly as fertilizer level increased from M1 (182.4 kg/ha) to M3 (295.7 kg/ha). Interaction effect of density and fertilizer levels increased yield in combination of high tree density and the highest level of fertilizers (S2M3-287 kg/ha and S3M3-418.7 kg/ha) and it was significantly superior to rest of the combinations. Similarly the combinations S2M2 and S3M2 are significantly superior to all the three densities with the lowest fertilizer level and combination of the lowest tree density with medium and higher levels of fertilizer (S1M2 and S1M3). The combination S1M1 yielded the lowest of 111.3kg/ha

2.2 Canopy management 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 annually soon after the harvest of the crop

since 1995 onwards. Canopy redevelopment by limb pruning (beheading the old exhausted canopy) was done during the period between May – June 2003.

The beheaded stumps of trees put forth new sprouts from dormant buds and new canopies were formed. In varieties like VTH 30/4 and NRCC Sel-1, pruned trees mostly remained vegetative in first fruiting season after pruning and in NRCC Sel-1, the trend continued in second season also as more than 50% flushes remained vegetative. In varieties like VRI-1 and Ullal-1 more thn 60% of new flushes flowered and fruited though the yield was less than control in the first season after pruning while, in the second season yield was significantly superior over control. The flowering and fruiting was delayed in pruned plants by 20-25 days in all the varieties upto second season of fruiting.

In the third fruiting season after beheading, the trees behaved on par with unpruned trees in flowering and fruiting time. In pruned trees almost all the new lateral shoots flowered. The yield in pruned plants was significantly superior in all the four varieties (Table 2.1). Different pruning treatments imposed such as yearly pruning, pruning once in two years and shape pruning for the maintenance of the canopy did not vary in yield performance.

In the observational trial on shape pruning to train seven year old plants of variety Ullal-3, all the plants in centre leader, modified leader or vase systems canopies was over crowded in the allotted 5M x 5M spacing and yield was low (<2kg) due to over shading. The bush shape pruned plants were shy bearers and low yielders during 6^{th} and 7^{th} year due to more of vegetative growth though they were properly exposed to sunlight.

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

2.3.1 *Expt (B). Evaluation of different soil and water conservation measures in relation to soil moisture availability and yield of cashew plantations grown in steep slopes*

Five treatments namely, modified crescent bund, staggered trenches with coconut husk burial between two rows of cashew, reverse terrace, catch pits and control plot without any soil and water conservation measures were laid on steep slopes in RBD with four replications having 25 plants each of is *Madakkathara-2* in the year 2003.

Staggered trenches with coconut husk burial

Modified crescent bund

Reverse terrace

2.3.2 Soil moisture studies

Soil samples at 0-30 cm, 30-60 cm and 60-90 cm depths were collected within 1 m radius of the plant, inside the trenches and between the two rows of plants from January 2006 to May 2006 and soil moisture content (SMC) under the different treatments was determined. Maximum SMC was observed in the case of modified crescent bund treatment (17.1 to 20.7 % db in January; 15.9 to 19.8%db in February; 12.5 to 15.8% db in March; 10 to 12.5% db in April and 22.6 to 24.0% db in May) and staggered trenches with coconut husk burial treatment (16.7 to 20.3% db in January; 15.2 to 18.3 % db in February; 12.1 to 16.2 % db in March; 9.6 to 13.2% db in April and 21.6 to 23.6% db in May) compared to control (14.7 to 17.6 % db in January, 11.1 to 14.2 % db in February;

10.0 to 13.1 % db in March; 9.5 to 11.5% db in April and 16.8 to 17.8% db in May) with no soil and water conservation structure. The variation of SMC at three different depths of the soil during the month of March 2006 is presented in Table 2.2. It was found that the SMC in all the three layers of soil in the modified crescent bund, staggered trenches with coconut husk burial and reverse terrace treatments were in the available soil moisture range (12 to 22 % dry basis) and the SMC in the first two layers of soil in the control plot was below the available soil moisture range in March itself. There was no precipitation from November 2005 to April 2006. In May, the soil samples were collected after a rainfall of 49.4 mm and maximum rainwater was stored in the treatments with soil and water conservation structures. The mean SMC of the three layers of soil in different treatments from January to May are presented in Table 2.3. It was found that upto March the mean SMC in all the three best treatments (19.0 to 13.3% dry basis) were in the available soil moisture range (Table 2.3).

2.3.3 Runoff and soil loss

Soil runoff measurement equipment was installed to measure the extent of soil erosion in the three best treatments and the control plot. Minimum runoff was observed in the case of modified crescent bund (22.4% of annual rainfall), staggered trenches with coconut husk burial between two rows of cashew (19.3% of annual rainfall) and reverse terrace treatments (24.5% of annual rainfall) compared to control plot (37.7% of annual rainfall). An annual rainfall of 2922 mm was recorded. Minimum soil loss was also observed in the case of modified crescent bund (2.9 t/ha/yr), staggered trenches with coconut husk burial (2.9 t/ha/yr), reverse terrace treatments (3.8 t/ha/yr) compared to control plot (4.1 t/ha/yr).

2.3.4 Nutrient status of the soil

The nutrient status of the soil in the staggered trenches with coconut husk burial (242 kg N: 35.4 kg P: 125.3 kg K / ha), modified crescent bund (244 kg N: 30.1 kg P: 120.6 kg K/ha) and reverse terrace treatments (223 kg N, 29.4 kg P and 118.4kg K / ha) were higher than the control (210 kg N, 21.6 kg P and 115.5 kg K / ha).

2.3.5 Growth observations

Higher increase in stem girth, canopy spread and plant height were also observed in the case of modified crescent bund (29.73 cm, 2.80 m and 2.29 m), staggered trenches with coconut husk burial (26.30 cm, 2.30 m and 2.15 m) and reverse terrace

treatments (26.30 cm, 2.62 m and 2.42 m) compared to control (24.3 cm, 2.12 m and 1.97 m).

2.3.6 Nut yield

Increased yield in the first harvest was also observed in the case of staggered trenches with coconut husk burial (0.390 t/ha), modified crescent bund (0.355 t/ha) and reverse terrace treatments (0.336 t/ha) compared to control (0.262 t/ha) plot without any soil and water conservation structures.

Table 2.1: Effect of beheading of trees on yield of cashew (kg)

Varieties	Pruning treatments			
	No pruning (P_1)	Yearly pruning (P_2)	Alternate year pruning (P_3)	Shape pruning (P_4)
VRI-1 (V_1)	6.11	9.24	8.53	8.25
Ullal-1 (V_2)	4.81	9.60	10.95	10.02
VTH 30/4 (V_3)	5.68	9.81	10.69	11.11
NRCC Sel-1 (V_4)	5.74	8.52	8.98	9.17
CV	13.10%			
CD (0.05)		1.75		

Table 2.2: Mean soil moisture in March 2006(% dry basis)

Treatment	Depth (cm)			Mean
	0-30	30-60	60-90	
Modified crescent bunding	12.5	13.8	15.8	**14.0**
Staggered trenches with coconut husk burial between 2 rows of cashew	12.1	13.4	16.2	**13.9**
Reverse terraces	12.0	13.1	14.9	**13.3**
Catch pits	10.2	11.5	13.2	**11.6**
Control plot without any soil and water conservation measure	10.0	11.1	13.1	11.4
Mean	11.3	12.6	14.6	
CD Treatment				1.31
CD Depth				0.42

Available soil moisture ranges from 12 to 22% dry basis

Table 2.3: Mean soil moisture during January to May 2006(% dry basis)

Treatments	Mean soil moisture				
	Jan	Feb	Mar	Apr	May
Modified crescent bunding with vetiver	19.0	17.8	14.0	11.1	23.1
Staggered trenches with coconut husk	18.0	16.9	13.9	11.4	22.5
burial between 2 rows of cashew	17.7	16.6	13.3	10.8	22.0
Reverse terraces	16.6	15.7	11.6	10.6	18.7
Control plot without any soil and water conservation measure	16.2	12.7	11.4	10.4	17.3
CD Treatment	2.01	1.96	1.31	0.37	0.48
CD Depth	0.68	0.59	0.42	0.25	0.17

3. CROP PROTECTION

3.1 Cashew Stem and Root Borer (CSRB)

3.1.1 Post extraction prophylaxis (PEP)

Under the trials on post extraction prophylaxis (PEP),trees which had pest incidence and without yellowing of the canopy were identified and treated by extracting the pest at different stages occurring in the stem and root zone. Later, these trees were treated by swabbing and drenching with sufficient quantity of chlorpyriphos solution at 0.2% and 0.4%. The percentage of trees without reinfestation was maximum in chlorpyriphos (0.4%) treatment (85.0%) followed by chlorpyriphos (0.2%) treatment (70.7%) and untreated control (66 %). The minimum duration of recurrence of infestation varied between 70 days to 130 days in various treatments.

3.1.2 Phytosanitation trials

The effect of adopting phytosanitary measures viz., uprooting of dead CSRB infested trees and infested trees beyond recovery (trees having > 50% of the bark circumference damaged and / or having yellowing of canopy) along with extraction of pest at different stages from initial and moderately infested trees, on the subsequent pest incidence is being evaluated since 2003-04.

The percentage of cashew trees (both healthy and previously infested) having fresh pest incidence reduced over the years in all the plots wherein phytosanitation was adopted. The reduction in infestation ranged between 21.45 to 60.98 per cent compared to the corresponding previous year. Further, the number of CSRB grubs encountered was also found to decrease over the years indicating gradual reduction of pest inoculum (Figs. 3.1 to 3.3).

3.1.3 Semi synthetic diet

The semi-synthetic diet consisting of host bark, bengal gram flour as a base and several other nutritional constituents has been standardized. Preliminary trials on rearing of CSRB grubs on this diet indicated that the SSD was palatable to the grubs. The weight gained by CSRB grubs both on SSD and host bark was similar. The CSRB grubs reared on host bark had slightly higher body weight.

3.1.4 Laboratory evaluation of larval parasitoid of coffee white stem borer (*Apenesia* sp.) for parasitisation of CSRB grubs

The grubs of CSRB aged 45 – 90 days were provided with the adult female of larval parasitoid of coffee white stem borer (CWSB) *Apenesia* sp. procured from Central Coffee Research Institute (CCRI), Balehonnur for parasitisation. Egg laying on CSRB grubs was noticed at a low level and the females of *Apenesia* showed a strong maternal care after oviposition. Survival of the parasitoid larvae on CSRB grubs was very low.

3.1.5 Survey for pests of stored cashew nuts and kernels

Four cashew processing units located in and around Puttur were surveyed for incidence of insect pests in the stored cashew nuts and processed kernels. It was observed that all the processing units adopted storage of cashew nuts in gunny bags and had stored testa and shells in the vicinity of the processing area. Incidence of *Tribolium castaneum* was severe in the stored testa. *Ephestia cautella* was also observed in stored testa to a lesser extent. In processed kernels collected from three processing industries , damage by *Ephestia cautella* and *Rhyzopertha dominica* was also noticed.

3.2 Lepidopteran flower and fruit pest of cashew

In the west (coastal Karnataka) and east coasts (Tamil Nadu), four species of lepitopteran flower pests of same types were encountered. Among them, the common apple and nut borer (*Thylacoptila paurosema*) infests both flowers and fruits and its larval hymenopteran parasitoids (two species) was observed during December 2004 to April 2005. The larval parasitism ranged from 32.8 to 46.2 %. In the west coast, larval parasitism upto 25.0 % was recorded on the shoot tip caterpillars (*Hypatima haligramma* and *Anarsia epotias*), whereas, in the east coast at only one location larval parasitoid of one species was collected. In the *Teri* coastal area (traditional cashew area) of Thuthoogudi district, Tamil Nadu, severe incidence of leaf and blossom webber (*Lamida monucusalis)* on panicles and developing fruits were observed. The spider *Oxyope*s sp. and ant, *Camponotus* sp. were observed in all locations as general predators. At Vridhachalam, ant (*Monomorium* sp.) caused damage to flowers by removing anthers and style.

In order to estimate the yield loss due to lepidopteran flower and fruit pests, 110 paired panicles on 7 to 10 days after initiation of flowering were tagged at random on eight trees and half the number of panicles were protected with λ-cyhalothrin

treatment as dip method twice at three weeks interval. The untreated panicles were excluded from tea mosquito (TMB) by mechanical killing daily. On 60th day, the pairs of panicles having TMB attack were omitted and finally 101 pairs of panicles without any TMB damage were observed to record final harvestable fruit set due to impact of flower pests. The protected panicles recorded 4.69±0.32 fruits/panicle whereas, unprotected panicle having flower pest damage and without any TMB damage recorded only 1.64±0.19 fruits/panicle (Table 3.1). Thus in the absence of TMB attack, with timely protection of lepidopteran flower pests alone lead to about two fold increase in yield.

Two insecticides (λ-cyhalothrin 0.003% and carbaryl (0.1%) were sprayed in a large plot having 110 trees with three rounds of sprays. But overall symptom of damage on panicles was recorded on 12 trees/treatment (52 panicles/tree) after third round of spray. In the untreated control 99.8 % of panicles had symptoms of damage, whereas, λ-cyhalothrin (0.003%) and carbaryl (0.1%) treated trees had shown damage symptoms on 2.7 and 21.1 % panicles respectively. Further, immediately after first, second and third sprays, the numbers of flower infesting caterpillars were collected by drop cloth method at the ground level of the tree. Six hours after spread of cloth, the larvae fallen on the cloth were counted. Flower infesting caterpillars were collected only after first and second spray and 1.95 and 0.25 and 0.5 and 1.2 caterpillars/m^2 were collected in cyhalothrin and carbaryl treatments respectively in a significant level indicating the overall population load of the pest. After third round of spray, flower pests collected were very low (Table 3.2).

3.3 Foraging behaviour of pollinators of cashew

Under west coast condition (Coastal Karnataka), six species of hymenopterans maintained constancy on cashew flowers. *Pseudapis oxybeloides, Lasioglossum* sp., *Braunsapis* sp., *Ceratina heiroglyphica, Pithitis smargdula* and *Halictus* sp. Among them, halictid bee *P. oxybeloides* was found to be predominant. The honeybees were regularly sighted on cashew flowers of early types. At Shantigodu, where abundant forest growth was available, visit of *Apis flore*a was very common on early flowering cashew types. Further, honeybees visited female flowers and collected nectar only. When such bees were collected and examined, those were loaded with slimy cashew pollen grains in a very low level in their respective corbiculae. Whereas in the east coast (Tamil Nadu), visit of hymenopteran bees was at a very low level. *Homalictus* sp., *Braunsapis* sp., *Pithitis smargdula* and *P. oxybeloides* were observed. Among

them, *Homalictus* sp. was found to be quite prominent in the traditional cashew areas. In the Coastal Tamil Nadu also, the activities of honeybees including rock bees were very low. Under Coastal Karnataka, during off-season, halictid bees sustain on herbaceous weeds (*Spermacoce ocymoids*, *S.stricta*, *Mimosa pudica* and *Leucas aspera*) and shrub (*Caesalpinia mimosoides).*

In the Coastal Tamil Nadu, even though *S. stricta* was noticed in all cashew plantations, none of above mentioned pollinators was seen. Whereas, *Ocimum americanum* and *Leucas aspera* sustained all the above pollinators mentioned under coastal Tamil Nadu including honeybees only in traditional cashew areas. During off-season, all the above bees and also honeybees were sighted on batches of *Ocimum americanum* that existed only in isolated patches. However, during recent visit to Pampadumparai (March 2005) wherein cashew was grown as a new crop and *A. florea* was found to be abundant (5 bees sighted within 10 min time) in conjunction with two major weed sources (*O. americanum* and one unidentified labiatae plant). Even though such bees mainly feed on nectar source, cashew pollen load on the body was sparingly seen on the body hairs and slimy pollen load was also prominently seen on their corbiculae. In Killikulam Agricultural College cashew orchard, constancy of *P. oxybeloides* was observed on *Cleome viscosa* (Fam: Capparidaceae)

The extent of pollination was assessed by observing deposit of pollen grains on the stigma of hermaphrodite flowers (Table 3.3). The extent of pollination, in Vridhachalam, was found to be at a very low level (18.8%) indicating the pollination deficiency. It was clearly seen from cluster bearing VRI-2 variety wherein fruit set in clusters at lower region of canopy (4.2 nuts/panicle) was significantly higher than the top of canopy (1.7 nuts/panicle). This type of variation in fruit set is mainly due to gravitational fall of pollen grains from upper panicles to lower panicles at lower regions of canopy and inadequate activities of insect pollinators on the upper regions of canopy.

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

3.4 Studies on the determination of insecticide residues in cashew kernels

3.4.1 Residues of insecticides in the samples collected from treated plots

Kernels obtained from cashew nut samples collected from plots treated with λ-cyhalothrin (0.003%) at NRCC Experimental Station, Shantigodu were analysed for the residues in collaboration with Cashew Export promotion Council of India (CEPCI), Quality Control, laboratory, Kollam. Residue of this insecticide was not detected in the kernels at detection limit of 100ppb .

3.4.2 Residues of insecticides in the samples collected from farm gate

Kernels obtained from the samples collected from Vridhachalam in Tamil Nadu were analysed for the residues of endosulfan, carbaryl, lindane and chlorpyriphos which are recommended for the management of pests of cashew residues in collaboration with Cashew Export promotion Council of India (CEPCI), Quality Control, laboratory, Kollam. Residues of all these insecticides were not traced in the kernels at a detection limit of 100 ppb.

3.5 Evaluation of newer insecticides against tea mosquito bug (TMB)

3.5.1 Efficacy of fenpropathrin under field condition

Fenpropathrin (Meothrin 30 EC) supplied by M/S Sumitomo Chemical, India, Mumbai was evaluated against TMB under field condition and three sprays were given at flushing, flowering and fruiting stages. Damage on shoots was assessed after one month of third spray in 0 - 4 scale. The damage grade was recorded on 52 shoots in each tree and the mean damage was worked out. The damage rating in fenpropathrin (0.02%)(0.14%) was on par with the recommended insecticides λ-cyhalothrin (0.003%) (0.25). In untreated check, the damage rating was 1.03. There was no significant difference in the natural enemy complex in the treated and untreated control plots. The average number of predators/panicle ranged from 0.66 – 0.71 in the fenpropathrin treated plots compared to 0.76 in the untreated control. In the laboratory confirmatory trial, the insecticide was found to induce 100 % mortality of both nymphs and adults of TMB suggesting the higher toxicity.

3.5.2 Evaluation of spray oil

Spray Oil supplied by M/S Indian Oil Corporation, Mumbai was evaluated against TMB under field condition and three sprays were given at flushing, flowering and fruiting stages. Damage on shoots was assessed after one month of third spray in 0 - 4 scale. Spray oil at both 1 and 2 per cent concentration was inferior to recommended insecticide λ- cyhalothrin (0.003%). The damage rating was in the range of 0.43-0.71 in spray oil treatment compared to 0.25 in λ- cyhalothrin.

Table 3.1: Yield loss assessment due to lepiopteran flower and fruit pests.

Details	Protected	Unprotected
No. of panicles tagged at random	110	110
No. of panicles without TMB damage	101	101
% of panicles had harvestable fruit set	91.8	62.7
% increase over unprotected	46.4	-
Mean no. of harvestable fruits per panicle	4.69 ± 0.32a	1.64 ± 0.19 b
Relative variation (%) of harvestable fruits	6.82	11.29
Range of harvestable fruits per panicle	0-14	0-11
% fruit borer damage	0.0	2.8

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

Table 3.2: Evaluation of promising insecticides against flower pests in large plot trial

Treatment	Flower infesting caterpillars* (No/m^2) after			Pest damage on panicles	
	1st spray	2nd spray	3rd spray	Flower pests (%)	Tea mosquito (0-4 scale)
Carbaryl 0.1%	0.50	1.20	0.15	21.1Cb	0.06Ba
λ-cyhalothrin 0.003%	1.95	0.25	0.00	2.7Ba	0.01Ba
Control	N.R	N.R	N.R	99.8A	3.78A

* Estimated by drop cloth method.
Figures in parentheses indicate the percentage over control
N.R : Not recorded.
Values in a column followed by capital letter indicate the comparisons of untreated control versus respective chemical treatment and by small letter indicates comparison between chemical treatments. Values in a column followed by common letter of any category are not significant by paired 't' test at 5% level.

Table 3.3: Extent of pollination in different varieties/accessions of cashew.

Variety/ Accession	Extent of pollination (%)#
Vengurla-1	40.8
Vengurla-4	46.7
Goa 11/6	44.4
NRCC-2	49.5
Ullal-3	36.2
Dhana	30.3
Vridhachalam-3	
Shanthigodu	41.7
Vridhachalam-RRS	18.8
Tirunelveli	43.7

Observed through stereoscopic dissection microscope

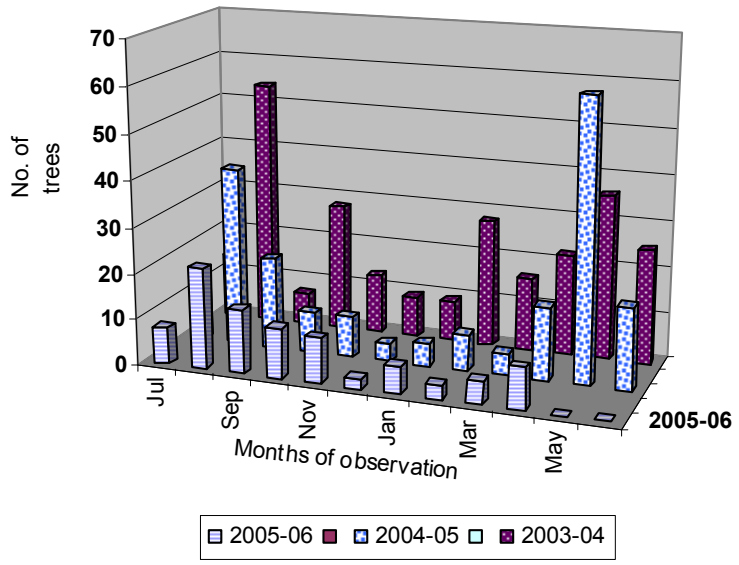


Fig.3.1: Number of trees freshly infested by CSRB in canopy management studies

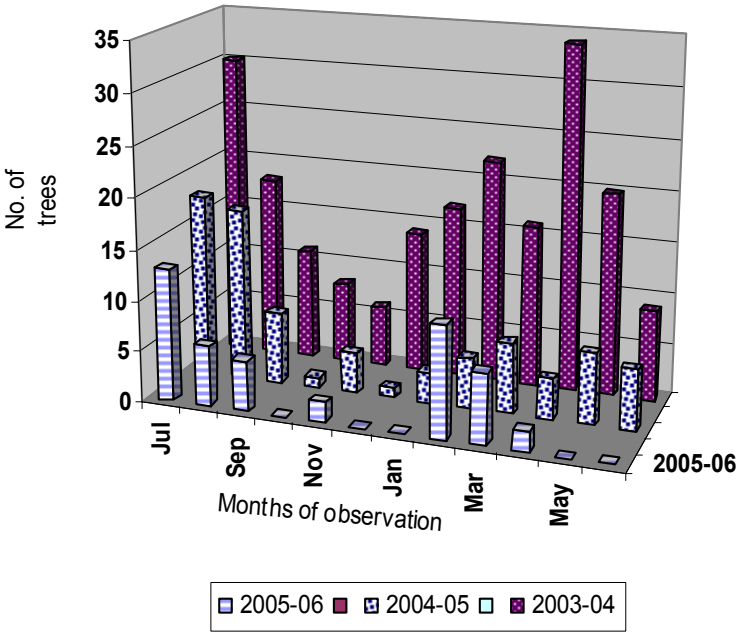


Fig.3.2: Number of trees freshly infested by CSRB in intercropping trials

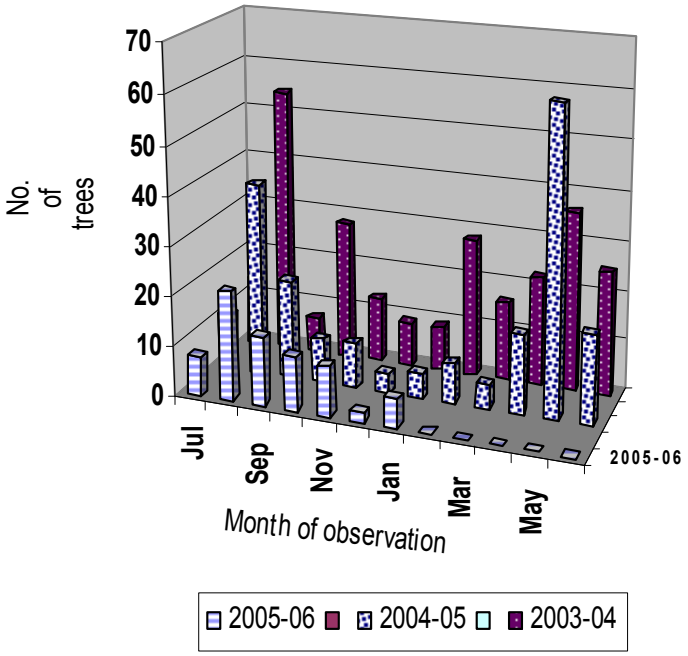


Fig. 3.3: Number of trees freshly infested by CSRB in drip irrigation trials

4. POST HARVEST TECHNOLOGY

4.1 Nutraceuticals

4.1.1 Extraction of pectin from cashew apple powder

Pectin from cashew apple powder (Red autoclaved and dried at 70°C for 2 days) was extracted with different extractants (Table 4.1). The yield of pectin varied with the extractant used (1.88 – 4.09%). Pectin extracted with 0.05 NHCl had very low ash content (1.15%). Per cent purity of pectin extracted with different solvents varied between 19.23 and 25.61%. Although, methoxyl content and acetyl content varied, the variation was not significant. Cashew apple pectin is a low methoxyl pectin (5 to 6.3%). Pectin ash contained Na (1.99 – 42.82 µg/mg), K (6.46 – 237.9), Ca (4.23 – 206.13) and Mg (1.6 – 19.43). Pectin extracted with distilled water at pH 5, had highest Na, K and Ca concentration/mg ash compared to other extractants.

4.1.2 Studies on cashew apple crude fibre and antioxidants

Sun dried cashew apple powder of different released varieties was analysed for its composition and the variability noticed among different varieties is presented in Table 4.2. Varietal variation with respect to the composition of sun dried cashew apple powder has been observed. Extraction of proteins from cashew apple powder of released varieties with water, alkali and salt was attempted. Extraction of proteins with 0.05 N NaOH was maximum compared to distilled water and 0.25 M NaCl. Variations in the extraction of proteins in different solvents among released varieties is presented in Table 4.3. Antioxidant activity of methanol extract of sundried cashew apple powder and total phenols in the methanol extract after fractionation using ion exchange resins of released varieties were analysed (Table 4.4). Higher antioxidant activity is associated with higher phenol content. Blends of cereals (rice, ragi and wheat flour) with cashew apple powder (autoclaved and dried) at concentration ranging between 5 and 20% were prepared and antioxidant activities in methanol extract was determined. Antioxidant activity increased with increased concentration of cashew apple powder compared to control cereal flours.

Table 4.1: Extraction of pectin from cashew apple powder.

Extractant	Yield (%)	Ash (%)	Purity (%)	Eq. Weight	Methoxyl content (%)	Acetyl content (%)
0.5 Sodium hexa meta phosphate pH 4.0	3.95	16.21	19.23	428.89	6.3	0.862
0.5% Ammonium oxalic and oxalic acid solution pH 4.0	3.95	7.07	22.49	604.20	6.57	1.062
0.05 N HCl	4.09	1.15	21.15	1279.35	5.04	1.084
Distilled water pH 5.0	1.88	2.68	25.61	1137.46	5.91	0.754

Values are mean of three individual estimations

Table 4.2: Composition of sun dried cashew apple powder of released varieties

Constituent	Variability
Protein[a]	2.28 – 12.29
Starch[a]	6.75 – 28.66
Sugars[a]	11.14 – 42.37
Vitamin C[f]	42.27 – 167.39
Tannin[c]	0.267 – 2.341
Crude fibre[g]	1.99 - 4.7
Pectin of crude fibre[g]	5.2 – 18.91
IDB of crude fibre[b]	0.197 – 3.783
IDB of CA powder[b]	0.8 - 17.21
Carotennids[d]	0.08 – 0.288
Anthocyanins[d]	11.78 – 34.38
Peroxides[e]	0.8 – 3.575

Values are mean of three individual estimations.
a– mg/100 mg, b – mg maltose released/3h/100 mg, c – mg/g, d – OD units/g, d – OD units/g, e – n moles MDA 100/mg, f - µg/100 mg, g - µg galacturonic acid/mg fibre

Table 4.3: Extraction of proteins from sun dried cashew apple powder of released varieties.

Extractant	Protein extracted (mg/100 mg)
Distilled water	0.122 – 0.549
0.25 M NaCl	0.082 – 0.483
0.05 M NaOH	0.8 – 2.104

Values are mean of three individual estimations.

Table 4.4: Antioxidant activities and phenol contents of methanolic extract of sundried cashew apple powder of released varieties.

Antioxidant activity	
DPPH activity (µ moles scavenged/15 min/ 100 mg)	0.58 – 2.861
Reducing power (A 700/20 min / 100 mg)	19.14 – 51.98
Total phenols (µg/100 mg)	27.93 – 269.58

Values are mean of three individual estimations.

5. TRANSFER OF TECHNOLOGY

5.1 Establishment and monitoring of model clonal cashew gardens

For laying out new demonstration 15 plots were selected. On ICAR Foundation Day the selected farmers were imparted training on Cashew Production Technology and planting material was distributed for establishment of demonstration plots. The demonstration farmers of the existing demonstration plots were provided technical guidance based on the condition of the plots during the visit of team of scientists.

5.2 Organizing farmers' training programmes

A thematic campaign on "SWC measures in cashew and HDP and Pruning in Cashew" was organized at Kavdichar village of Puttur taluk in collaboration with SKDRDP, Puttur on 2-7-2005. A total of 75 farmers participated. A training programme on "Cashew Production Technology" was organized at Vorkady, Kasaragod district of Kerala on 30-7-2005 in collaboration with Farm Information Exchange Club, Vorkady. A total of 40 farmers participated. Training programme on 'Cashew apple utilization' was organized for farm women in collaboration with SKDRDP, Puttur on 25.4.2006. Methods of preparation of cashew apple products were demonstrated in which 45 farm women participated.

5.3 Organizing training programmes for development personnel / SHG members

The following training programmes were organized for the officials of Development Departments / SHG members.

Name of the programme and date	Sponsoring Agency	Type and No. of participants
Vegetative Propagation of Cashew (17-18, August, 2005)	KCDC Ltd., Mangalore AHADS, Agali, Kerala	Officials (17)
Vegetative Propagation of Cashew (28-9-2005)	SKDRDP, Puttur	SHG Members (20)

Pruning, Topworking and Composting of Cashew Biomass (14-16, December, 2005)	AHADS, Kerala KCDC Ltd., Mangalore OSCDC Ltd., Orissa DOH, Meghalaya Aralam Farm, Kannur, Kerala DOH, Chattisgarh	Officials (17)
Composting of Cashew Biomass (17 December, 2005)	PCKL, Kerala	Officials (10)
Cashew Production Technology (21-23 January 2006)	DOA, Kerala, DOH, Tripura, DOH, Meghalaya, KCDC Ltd., Karnataka	Officials (17)

5.4 Cashew Day

Annual Cashew Day was organized on 14-3-2006 with a theme of "Increasing yield of cashew orchards". Field visits to experimental plots at both campuses were arranged to educate the farmers on the latest technologies in cashew cultivation. An exhibition was also arranged. A seminar was arranged on the theme during which progressive farmers and scientists shared their experience with the farmers. There was a question and answers session after the seminar during which the various doubts raised by the farmers were clarified by the scientists and officials of Development Departments. More than 250 farmers participated.

5.5 TV serial on "Improved cashew cultivation practices"

A TV serial on Improved Cashew Cultivation practices was telecast in collaboration with E-TV Kannada through Annadata Kannada with 11 episodes on important topics on CPT including, Introduction about NRCC, Puttur; Softwood grafting technique in cashew; Establishment and Management of cashew orchards; Management of CSRB; Inter and mixed cropping in cashew; Canopy management in cashew; Management of TMB; Preparation of compost and vermicompost from available cashew biomass; Experience of a farmer in commercial preparation of vermicompost; Experience of a farmer in high density cashew cultivation and Experience of a farmer in cultivating cashew in degraded soils.

5.6 Socio-economic Impact of Cashew Cultivation

5.6.1 Maharashtra

Data was collected from randomly selected 30 graft and seedling cashew growers of Sindhudurg district to assess the socio-economic impact of cashew cultivation in Maharashtra. Apart from cashew growers, officials of Development Departments and cashew researchers were also contacted for collecting the relevant data.

"Less labour intensive nature of the crop, less market problem, for utilizing the degraded lands, profitable nature of the crop, fewer pests and disease problem, less supervision required, due to government scheme and neighbours / friends" were the major reasons as told by the cashew growers for starting cashew cultivation.The seedling growers had a mean age around 50 and middle school level of education. They were small farmers with a mean cashew area of two acres and a population of 127 trees / ha. The graft farmers had a mean age of 47 and high school level of education. They were large farmers with mean cashew area of five acres and a population of 153 trees / ha. Both the type of farmers had more than twenty years of cashew experience. The knowledge, adoption and perception level of the seedling farmers were significantly less than that of the graft farmers whereas the technology gap of the seedling farmers was significantly more than that of the graft farmers (Table 5.1). The difference between adoption gap of the seedling and graft farmers was wider for the practices viz., initial training and pruning, plant protection measures against tea mosquito bug(TMB) and cashew stem and root borer (CSRB)and application of manures (Table 5.2).

As a result of cashew cultivation, both seedling and graft farmers experienced purchase of new lands, leasing in and out of cashew area. The increase in labour engagement, social participation, mass media exposure of graft farmers as a result of cashew cultivation was double than that of seedling farmers. However both the farmers experienced increase in farm expenditure, farm income and family expenditure as a result of cashew cultivation. The cost of cashew cultivation/ha incurred by graft farmers was almost Rs. 5000/- more than that of seedling farmers. However, the yield of cashew / acre of graft farmers also was more than 1.5 times that of seedling farmers.

Establishment of cashew orchards, high density planting, plant protection measures, cashew apple processing, cashew nut processing, application of manures, Cashew Production Technology and training and pruning were the major aspects in which the cashew growers of the study area need training The major constraints expressed by

both the types of farmers were, damage due to the attack of TMB, damage due to the attack of CSRB, labour unavailability, high labour cost, insufficient schemes / programmes for cashew from the Development Departments. Cashew area expansion with quality cashew grafts, rejuvenation of old gardens with better genetic material, replanting programmes with better compensation/ subsidy, intensive training programmes and campaigns to popularize the important cashew cultivation practices recommended, training of the farmers on timely adoption of cashew cultivation practices and promoting cluster approach for marketing cashew nuts processed through small scale processing units, were the important strategies suggested by the cashew researchers and officials of Development Departments to improve the cashew cultivation scenario of the district.

5.6.2 Andhra Pradesh

Data was collected from randomly selected 58 graft and 62 seedling cashew growers of seven cashew growing districts of the state viz., Srikakulam, Vizhianagaram, Vishakapatnam, East Godhavari, West Godhavari, Kammam and Ongole to assess the socio-economic impact of cashew cultivation in Andhra Pradesh. Apart from cashew growers, officials of Development Departments, cashew researchers, nursery owners and cashew processors were also contacted to collect the relevant data.

Less labour intensive nature of the crop, less supervision requirement, profitable nature of the crop, suitability to the of the soil available, non remunerative nature of other crops like paddy due to less irrigation facility, least market problem, availability of subsidy scheme, intercrops can be accommodated and the neighbours' experience were the motivation factors responsible for cashew cultivation in the study area. The seedling and graft farmers had a mean age around 45, middle school level of education and 25 years of farming experience. They were large farmers with a mean cashew area of 12-16 acres. Plant population was 45 and 65 trees / acre as possessed by seedling and graft farmers respectively. The share of cashew area was two thirds of the total farm size for both the farmers. The knowledge, adoption and perception level of the seedling farmers were significantly less than that of the graft farmers whereas, the technology gap of the seedling farmers was significantly more than that of the graft farmers (Table 5.1). The difference between adoption gap of the seedling and graft farmers was wider for the practices viz., planting technique, irrigation and application of manures (Table 5.2).

Absentee landlordism in larger cashew plantation led to wastage of resources viz., labour, inputs and money. Larger plantations were leased to small cashew growers. The lease amount ranged between Rs. 2500 – Rs. 5000/acre. However, neither the land owners nor the lease owners adopted the recommended practices. The major practice adopted by land owners was ploughing the land as a water conservation measure whereas that of lease owners' was spraying once. Collection of immature nuts is prevalent due to the theft problem (mainly in Srikakulam district).The low yield in cashew and damage due to cashew pests lead to replacement of cashew by casuarina in Srikakulam, Vizianagaram, Vizhagapatnam districts and by oilpalm and eucalyptus in East and West Godavari districts. Small and marginal cashew growers preferred seedlings over grafts due to lack of irrigation facility. Involvement of middlemen in procurement of raw nuts resulted in reduction in the price of raw cashew nuts to the tune of Rs. 100-150/bag.Intercrops viz., watermelon, tomato, bhendi, capcium, carrot, cabbage and cauliflower etc ., were grown prevalently in cashew gardens. The lack of coordination in the pest management in larger cashew plantations available at stretches lead to ineffective pest management. Majority of the cashew plantations are of seedling progenies at neglected conditions. Even now in West Godavari areas, area expansion is done with seedling progenies.

Availability of good quality planting material is the major constraint in cashew growing regions of Andhra Pradesh. The quality of grafts produced in both private / government nurseries were not up to the recommended standards. The cashew processing industries located in Palasa, Tuni and Vettapalem areas used the drum roasting method which makes the conditions unhygienic for the workers. There is a stiff competition is prevailing among the cashew factories located in Palasa, Tuni and Vettapalem areas to procure raw cashew nuts. Analysis on cost of cultivation had shown that cost of cultivation incurred by graft farmers was almost double than that of seedling farmers. However, the yield of graft plantation with a mean age of 8 years was 1.4 times more that of seedling plantations with a mean age of 17 years.

Severe flower drying problem, damage due to pests viz., TMB,CSRB, thrips, apple and nut borer, mealy bug and mites, absentee landlordism prevailing in larger plantations, high temperature during fruiting season and continuous drought, unavailability of straight fertilizers, involvement of middlemen in procurement of raw cashew nuts, damage due to hailstorm, majority of the cashew orchards are with seedling progenies, unavailability of market in nearby areas for cashew in some areas, non adoption of improved practices recommended for cashew cultivation by the farmers and high cost and unavailability of agricultural labours were the major

problems in cashew cultivation in the study area.Plant protection measures, application of fertilizers, irrigation method, high yielding varieties recommended, canopy management, planting and aftercare and intercropping in cashew were the aspects in which the cashew growers need training.

Evaluation and recommendation of some of the recent mid and late flowering types such as VRI-3, Ullal-1, Ullal-3, Vengurla-4, Vengurla-7, Dhana, Madakkathara-2 and Bhaskara to escape the flower drying; following minimum graft standards in propagation by the approved nurseries for supply of quality cashew grafts; rejuvenation of the low yielding trees/unthrifty plantations by pruning/ limb pruning (wherever possible); soil and water conservation measures such as deep planting in bigger pits and application of coir pith and in later stages, maintaining 2 M radius terraces around the base of the plant, opening of catch pits on the upper side of terraces or terrace with crescent bund or coconut husk burial between two rows of cashew in slopy lands (tribal belt of Sreekakulam); protective irrigation of 200 litres/tree once in 15 days from January – March or drip irrigation (80 litres/plant) once in 4 days from January – April after 70% of flowering; phytosanitation in CSRB affected gardens by uprooting and destroying the severely affected and dead cashew trees on war footing; timely application of pesticides to control TMB and other sucking pests; training the department officials / farmers on various cashew production technologies; preparation and distribution of cashew literature on improved cultivation practices to literate farmers; training illiterate farmers through slides / film shows on cashew production technologies; establishing frontline demonstration on various cashew production technologies such as soil and water conservation, high density planting, inter and mixed cropping; limb pruning and pest management; organizing campaigns / field days on various aspects of cashew production and processing aspects and introducing homestead processing / co-operative processing to avoid the problems due to middle men were the strategies suggested to improve the cashew cultivation scenario of the cashew growing regions of Andhra Pradesh.

Table 5.1: Technology gap of the cashew growers

State	Category	Percent		't'value
		Seedling farmers	Graft farmers	
Andhra Pradesh	Low	27	10	7.0859**
	Medium	56	67	
	High	19	22	
	Mean	73	49	
Maharashtra	Low	0	10	14.9574**
	Medium	77	83	
	High	23	7	
	Mean	54	32	

** Significant at 5% level of probability

Table 5.2: Technology-wise adoption gap of the cashew growers

Technologies	Maharashtra		Andhra Pradesh	
	Seedling Farmers (%) (n=30)	Graft Farmers (%) (n=30)	Seedling Farmers (%) (n=62)	Graft Farmers (%) (n=58)
Planting technique	63	47	63	33
Soil and water conservation measures	83	60	73	74
Irrigation	84	63	94	66
Initial Training and Pruning	78	34	98	93
Plant protection measures against TMB	57	27	50	40
Plant protection measures against CSRB	60	37	66	66
Application of manures	64	33	55	35

6. COMPUTER APPLICATION

6.1 Computer Application in Cashew

6.1.1 Development of software package for allotment of cashew graft

Cashew graft allotment package was developed in Active Server Pages (ASP) by using VB and Java scripts. This is a server based package, which can be accessed in any client systems through Local Area Network. This was developed at this for monitoring the cashew grafts sales and stock at nurseries in order to avoid human errors and to save manpower. This package provides options like record entry, modification, deletion and reports. Different types of reports can be generated like, details of farmers, list of grafts allotted to farmers, stock at two nurseries of NRCC and graft allotment letters based on user query (under report option). The report prepared under ASP can be converted into a report of superior quality by using MS-Word as it has more options.

CONCLUDED PROJECTS

7. Concluded Project

7.1 Studies on determination of insecticide residues in kernels

Project Leader	Dr. P. Shivarama Bhat
Project Associate	Dr. T.N. Raviprasad
Project Number	3.6
Project Duration	6 years (2000-2006)

7.1.1 Introduction

Cashew suffers greatly due to pest menace throughout the country. Tea mosquito bug(TMB) and cashew stem and root borer (CSRB) are the two major pests which causing substantial yield reduction. Various chemical control measures are suggested against these pests. The cashew consumers both at national and international level are quality conscious and contamination of kernels with pesticides if any poses threat to cashew industry. Hence a project was undertaken to find out residues of insecticides in cashew kennels.

7.1 .2 Objectives

Studies were undertaken on determination of insecticide residues in cashew kernel with following objectives:

- Standardization of various methodologies for detection of insecticides residues from cashew kernels.

- Determination of level of residues of different insecticides used in the management of cashew in kernels.

- Documentation of levels of residues in cashew kernels wherever pesticides are used in cashew pest management.

7.1.3 Results and Discussion

7.1.3.1 Standardization of protocols for the determination of residues of the insecticides

Lindane

Two methods were followed for the detection of residues of lindane in cashew kernels. In the first method, powdered kernel sample was homogenized with 35% water in acetonitrile and recovery of residue was upto 87.5 % .In the second method, cashew kernels after homogenization in acetone was extracted with n-hexane with a recovery of upto 89.8 % of the residue.

Endosulfan

In the first method, the kernel sample was homogenised with 100 ml acetone-hexane (1:1, v/v) mixture and the recovery of residue was upto 86.5 % .In the second method, sample was homogenized with 125 ml of acetonitrile and water mixture (4:1) followed by extraction with n-hexane (150 ml). The recovery of the residues was upto 88.6%

Carbaryl

Carbaryl was hydrolised with NaOH and the resulting l-naphthol was treated with pyridine and trichloroacetyl chloride to produce trichloroacetate which was analysed by gas chromatograph fitted with ECD and recovery of the residue was 78.27% .

Chlorpyriphos

Kernel sample was extracted with n-hexane and partitioned with acetonitrile and the recovery of the residues was 80.27% .

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

Tea mosquito bug (TMB)

TMB is one of the serious sucking pests of cashew damaging the tender shoots, panicles, apples and nuts. Endosulfan, one of the earlier recommended insecticides for the management of TMB was sprayed at recommended concentration (0.05%) and double the recommended concentration (0.1%). Similarly carbaryl, one of the very commonly used insecticides for the management of TMB was sprayed at recommended concentration (0.1%) and double the recommended concentration

(0.2%).The nut samples were collected after 3, 7 and 14 days of treatment. Samples were also collected at the time of harvest. Residues of the insecticides sprayed were not detected in any of the samples analysed.

Cashew stem and root borer (CSRB)

CSRB is another serious pest of cashew affecting both stem and root of the cashew tree leading to death of the tree. The trees infested by CSRB were treated with lindane and chlorpyriphos, which are effective insecticides for the management of this pest. The treatment was done after removal of the grubs at recommended concentration and double the recommended concentration. The nut samples collected from the treated trees were analysed for the residues of both lindane and chlorpyriphos . All the samples were free from the residues.

7.1.3.3 Monitoring of levels of residues in the samples collected from the farmers'fields and farm gates

Rawnuts collected from the farmers' fields and farm gates were analyzed for the residues of the insecticides used in the management of TMB and CSRB. Samples were also got analysed at Cashew Export Promotion Council of India (CEPCI) laboratory at Kollam. The residues of endosulfan, carbaryl, chlorpyriphos and lindane were not detected in the samples analysed .

7.1.3.4 Documentation of levels of insecticides used in the management of cashew pests in other cashew growing areas

Rawnuts collected from maidan parts of Karnataka , Sindhudurg district of Maharashtra, Bapatla in Andhra Pradesh and Vridhachalam at Tamil Nadu were analyzed for the residues of insecticides used for the management of TMB and CSRB . The samples were also got analyzed at Cashew Export Promotion Council of India (CEPCI) laboratory at Kollam. The residues of the commonly used insecticides viz., endosulfan, carbary, chlorpyriphos, and lindane were not detected in the kernels of the samples analyzed.

7.1.4 Conclusion

Carbaryl, endosulfan, chlorpyriphos and lindane were the recommended insecticides for the management of TMB and CSRB in cashew. The kernels of the nuts collected from plots treated with these insecticides at recommended concentration and double

the recommended concentration were found to be free from residues. The kernels obtained from nut samples collected from the farmers' fields of Dakshina Kannada district of Karnataka were also free from the residues of all these insecticides. The kernels of the samples collected from major cashew growing areas of Tamil Nadu, Orissa and Mahrashtra and Karnataka were also free from the residues.

7.1.5 Publications

Bhat P.S and Raviprasad T.N. 2005 Studies on determination of insecticide residues in kernels. *Cashew News* 10(2):2-3.

Bhat, P.S. Sundararaju, D. and Raviprasad, T.N 2002. Integrated Management of Insects, Pests and Diseases In: Indian Cashew Industry. Ed. Singh, H.P. Balasubramanian P.P. and Venkatesh Hubballii, DCCD, Kochi. pp.111-117.

7.2 Mineral composition of cashew kernel, testa and apple pomace of released varieties

Project Leader	Dr. K.V. Nagaraja
Project Associate	None
Project Number	4.8
Project Duration	3 years (April – March 2006)

7.2.1 Introduction

Composition of cashew kernel, testa and apple and varieties with better biochemical composition have been reported. Minerals play an important role in human health. As the information on mineral composition of cashew kernel, testa and apple pomace of released varieties was not available, the present project was initiated.

7.2.2 Objectives

i) To analyze cashew kernel, testa and apple for minerals.

ii) To identify varieties with better mineral composition.

7.2.3 Results and Discussion

Defatted flour of cashew kernels, testa and cashew apple pomace of released varieties were analysed for Na, K, P, Ca, Mg, Fe, Cu, Zn and Se by AAS. Defatted cashew kernel flour of released varieties is rich in P and K. Significant variation among different varieties was observed. Se, a mineral which plays a significant role in prevention of cancer has been detected in 28 released varieties. Cu and Zn which act as antioxidants are detected in defatted cashew kernel flour. Iron is present in defatted kernel to considerable extent.

Significant variation among released varieties was noticed with respect to composition of cashew kernel testa. Se was not detected in most of the varieties analysed except Ullal-3, Ullal-4, UN-50, Dhana, NDR-2-1, Priyanka, Amrutha, Damodhar, Raghav, V-2, BPP-1 and VRI-3. Among different minerals analysed concentration of P is highest in most of the varieties. In some varieties, concentration of K and Ca was higher than P.

Significant variation among released varieties was noticed with respect to composition of minerals in cashew apple pomace. Se was not detected in most of the varieties analysed except Ullal-2, Sel-1, Chintamani-1, K-22-1, Bla-39-4, Dhana, Kanaka, Priyanka, V-1, V-2, V-3, V-4, V-6, Jhargram-1, VRI-2 and VRI-3. The concentration of P was higher than other minerals in all the varieties analysed. Range of concentration of different minerals present in defatted cashew kernel flour, testa and cashew apple pomace of released varieties is presented in Table 7.1.

Free and bound form of minerals in cashew apple pomace of released varieties was analysed by extracting the cashew apple pomace with 0.1 N HCl (free form) followed by wet digestion of residual cashew apple pomace with diacid mixture (bound form). Varietal variation was noticed with respect to free and bound form of minerals (Table7.2).

Cashew apple pomace blends with cashew kernel testa, almond testa, defatted cashew kernel flour and defatted almond kernel flour were prepared by blending in 1:1 ratio (w/w). Mineral composition of cashew apple pomace could be improved by blending with defatted cashew and almond flours (Table 7.3).

7.2.4 Conclusion

Varieties exhibit significant variation with respect to mineral composition of defatted cashew kernel flour, testa and cashew apple pomace. Mineral composition of defatted cashew kernel flour and testa of same varieties from different sources exhibited variation indicating the influence of soil fertility on the mineral composition. Mineral composition of cashew apple pomace could be improved by blending with defatted cashew or almond flours.

7.2.5 Publication

Nagaraja, K.V. 2006. Composition of cashew processing by-products. *J. Food Sci. Techol.* **43:**267-271.

Table 7.1: Range of concentration of different minerals in defatted kernel flour, testa and apple pomace of released varieties (µg / 100mg).

Minerals	Defatted kernel flour	Kernel testa	Apple pomace
P	17 - 1028 (Raghav) (Amrutha)	19.19 - 157.15 (BPP-3) (Ullal-1)	27 - 297 (VR1-1) (BLA 139-1)
Na	1.0 - 20.98 (Sel 1) - (VRI-4)	5.04 - 68.23 (BPP-9) (Ullal-4)	1.94 - 15.64 (Ullal-2) (UN 50)
K	10.27 - 788.1 (V-6) (Ullal-3)	10.25 - 240.87 (BPP-1) (Ullal-4)	13.79 - 19.68 (Ullal-2) (Jhargram-1)
Ca	5.55 - 74.51 (Ullal-2) (Bhubaneswar-1)	21.97 - 1235.45 (VRI-2) (Amrutha)	3.76 - 38.11 (K 22-1) (Jhargram-1)
Mg	16.63 - 32.62 (Raghav) (K 22-1)	13.15 - 69.32 (BPP-9) (Amrutha)	12.61 - 24.3 (Ullal-2) (Jhargram-1, VRI-1)
Cu	0.6 - 7.24 (BPP-1) (Chintamani-1)	0.19 - 8.37 (BPP-2) (Ullal-4)	0.49 - 5.83 (Priyanka) (BPP-1)
Mn	3.23 - 12.66 (VRI-3) (BPP-6)	4.44 - 24.62 (K 22-1) (V-6)	1.45 - 6.62 (Dhana) (BPP-5)
Zn	2.97 - 9.79 (VRI-3) (BPP-5)	1.42 - 9.03 (BPP-4) (BPP-6)	0.38 - 5.16 (Ullal-2) (Priyanka)
Fe	1.08 - 13.29 (V-2) (Sulabha)	1.6 - 20.23 (BPP-4) (Amrutha)	0.15 - 40.61 (Dhana) (BPP-5)
Se	0.98 - 13.77 (Anagha) (Ullal-1)	1.34 - 26.18 (Priyanka) (Ullal-4)	0.55 - 20.91 (V-1) (VRI-1)

Table 7.2: Variation of free and bound form of minerals in cashew apple pomace of released varieties (%)

Minerals	Free	Bound
Ca	49.2-100	0-50.8
Mg	68.0-90.6	9.4-32.0
K	61.9-96.4	3.6-38.1
Na	32.0-90.4	9.6-68.0
Cu	54.51-100	0-45.49
Mn	59.8-100	0-40.2
Zn	76.31-100	0-23.69
Fe	38.63-100	0-61.37
Se	65.2-100	0-34.8

Values are mean of three individual estimation

Table 7.3: Mineral composition of cashew apple pomace based blends (1:1 w/w)

Blends	P	Na	K	Ca	Mg	Cu	Mn	Zn	Fe
Cashew apple pomace + cashew kernel testa	112.25	3.39	52.36	15.83	31.7	2.46	3.81	2.33	3.69
Cashew apple pomace + almond testa	293.65	4.31	47.15	67.44	36.9	2.94	7.22	4.05	4.79
Cashew apple pomace +Defatted cashew kernel flour	452.00	4.76	14.37	12.74	6.34	4.09	1.7	3.4	2.69
Cashew apple pomace+ Defatted almond kernel flour	374.0	1.8	13.7	42.46	6.44	2.71	2.19	2.2	1.09
Cashew kernel testa + Defatted almond kernel flour	385.0	2.53	13.6	44.91	6.55	2.51	3.74	2.51	2.83
Almond kernel testa + Defatted almond kernel flour	519.0	2.05	13.68	58.24	6.7	3.57	6.79	3.41	4.01
Defatted almond flour	789.88	1.24	52.13	85.2	42.92	2.84	4.9	3.53	5.72

Values are mean of three individual estimation and expressed as µg/100 mg

EDUCATION / TRAINING / GENERAL / MISCELLANEOUS INFORMATION

8. EDUCATION AND TRAINING

- Training on “Vegetative Propagation of Cashew” was organized during 17-18, August, 2005 in which 17 trainees sponsored by development departments were trained on softwood grafting and nursery management. Similar training was also organized for members of Self-Helf Groups of SKDRDP, Puttur on 28-9-2005 in which 25 trainees have participated.

- Three days refresher course on “Pruning in Cashew and Composting of Cashew Biomass” was organized during 14-16, December, 2005 during which 17 officials of Development Departments were imparted training on Canopy Management in Cashew and Composting of Cashew Biomass through Japanese and Vermicomposting methods.

- A day long training on “Composting of Cashew Biomass” was organized for 10 officials of PCKL Ltd., Kerala during which the trainees were imparted training on Japanese and Vermicomposting of Cashew Biomass.

- A refresher course on “Cashew Production Technology” was organized during 17-19, January, 2006 during which 17 officials of development departments from various cashew growing states were imparted training on improved cashew cultivation practices.

9. LINKAGES / COLLABORATION

Name of the organizations	Type of collaboration
Central Food Technological Research Institute, Mysore	DBT Sponsored Project on nutraceuticals
Project Directorate of Biological Control (PDBC), Bangalore	EAG and GCMS studies
SKDRDP, Dharmasthala FIBC, Perla, Kasaragod Manaje Vyavasaya Sahakari Seva Society, Kamashile	Thematic campaigns, laying out demonstration plots, trainings and Annual Cashew Day
Directorate of Cashewnut and Cocoa and Development, Kochi	Farmers training progrmmes
Cashew Export Promotion Council of India, Kollam.	Insecticide residue analysis
Department of Horticulture, Karnataka Karnataka Cashew Manufacturer's Association, Mangalore. Agricultural Research Station, Ullal, Mangalore.	Farmers training programmes

10. AICRP-CASHEW CENTRES

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11. PUBLICATIONS

11.1 Research Publication

Raviprasad, T.N. Sundararaju, D. and Bhat P.S. 2005 Efficacy of botanicals against *Helopeltis antonii* Sig.infesting cashew. *The Cashew* **XIX(2)** :29.

Raviprasad, T.N., Sundararaju, D. and Bhat, P.S. 2005. Efficacy of plant extracts and commercial formulations against *Helopeltis antonii* Sig. (Miridae : Hemiptera) infesting cashew . The Cashew. XIX(4):9-14.

Shirly Raichal Anil and Thimmappaiah 2005. Somatic embryogenesis in nucellar callus of cashew (*Anacardium occidentale* L.) *J.Hort.Sci. & Biotech*. 80 (32):327-331

Sundararaju ,D. 2005 Seasonal abundance of tea mosquito bug and extent of damage on cashew . *J. Plantation Crops* **33:** 53-58.

Venkattakumar ,R. Raviprasad, T.N.and Nayak, M.G. 2005 Perception of demonstration farmers towards recommended soil and water conservation and plant protection measures of cashew. *J. Plantation Crops* **33(2)**: 135-137.

Yadukumar N. and Nandan, S.L. 2005 Recycling of cashew plantation waste by aerobic composting. *J. Plantation Crops* **33(2)**: 99-102.

11.2 Popular Articles

Bhat, M.G. and Nagaraja, K.V. 2005. Recent Advances in cashew research in India. In: Golden Jubliee Souvenir of the Karnataka Cashew Manufacturers Assocation, Suprabhat, Mangalore, Karnataka (Ed. Mr. G. Giridhar Prabhu and Others).

Bhat, M.G. and Venkattakumar, R. 2006. Progress of research – Cashew : In the Hindu Survey of Indian Agriculture, 2005. The Hindu, Chennai, Tamil Nadu.

Bhat, P.S. and Raviprasad, T.N. 2005 Studies on determination of insecticide residues in kernels. *Cashew News* **10(2)**:2-3.

Bhat, P.S. 2006. *Geru Krishiyalli chhaha solleya havali mattu nirvahane* (Tea mosquito bug damage in cashew and its management). *Krishika Bhandu* **3(9):**53-54.

Nayak, M.G. 2006. Vegetative Propagation and nursery management *Krishika Bhandu.* 3(9):58-59

Nayak,M.G. 2006. Training and pruning practices of cashew *Krishika Bhandu.* 3.

Yadukumar N. and Bhat P.G. 2005 Uttama gerubelege savayava gobbara (Organic manure for increasing cashew yield) *Adike Patrike* :17(9)

11.3 Papers presented in Symposia / Workshop / Seminar

Nayak, M.G. and Bhat, M.G. 2005. Mechanization of Production and Post-Production operations in cashew. In: ICAR Short Course on Mechanization of Production and Post-Production operations in Plantation Crops at CPCRI, Kasaragod on 22nd November, 2005.

Nayak, M.G. and Bhat, M.G. 2006. Biodiversity in cashew, its conservation and utilization efforts **In**: National Conference on Agro Biodiversity organized by National Biodiversity Authority, Kapaleeswara Nagar, Neelankarai, Chennai on 12-15th February 2006.

Sundararaju , D. 2005 Release proposal of cashew variety "Bhaskara". **In:** National Group Meeting of Scientists of AICRP on cashew held at KAU, Thrissur on 28-30 November 2005.

Sundararaju , D. 2006 Release proposal of cashew variety "Bhaskara".**In** : Karnataka State Variety Release Committee Meeting held at Secretariat, Government of Karnataka , Bangalore on 14th March 2006.

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

11.4 Book Chapters

Bhaskara Rao, E.V.V. and Swamy, K.R.M. 2005 Cashew. **In**: Handbook of Industrial Crops.Chopra, V.L. and Peter, K.V. (Eds) The Haworth Press Inc. New York. USA. Pp.77-136.

Bhaskara Rao, E.V.V., Swamy, K.R.M. and Bhat, M.G. 2005. Cashew. **In**: Plantation Crops Vol.2. Parthasarathy, V.A., Chattopadhaya, P.K. and Bose,T.K. (Eds). Naya Udyog, Kolkata pp179-282.

Bhat, M.G. 2005. Cashew Research in India – An Overview. In: Cashew Research and Development in Kerala. Kerala Agricultural University, Thrissur, Kerala. (Ed. Jose Mathew).

Nayak, M.G. and Bhat, M.G. Biodiversity in Cashew. 2005. In: Biodiversity in Horticultural Crops. Day Publishing Company, New Delhi. (Eds. Z. Abraham and K.V. Peter).

11.5 Technical Reports / Bulletins / Compendia

All Indian Coordinated Research Project on Cashew. 2005. Annual Report 2004-05. NRC Cashew, Puttur, Karnataka 130 pp

National Research Centre for Cashew. 2005. Annual Report 2004-05, Puttur, Karnataka, 68 pp.

National Research Centre for Cashew. 2005. Cashew News, Newsletter. Vol. 10 (1), Puttur, Karnataka. 8 pp.

National Research Centre for Cashew. 2005. Cashew News, Newsletter. Vol.10 (2), Puttur, Karnatka, 8 pp.

Bhat, M.G., Nayak, M.G. and Swamy, K.R.M. In: Technical Bulletin No. 71 “Technologies for production of quality see and planting material in Horticultural Crops” Ed: (Kalloo, G., Pandey, S.K., Chakraborti, S.K. and Kaushik, S.K.). Central Potato Research Institute, Shimla, India. Pp. 146-151.

Nayak, M.G. and Bhat, M.G. 2006. Cashew. In: Technical Bulletin on”Rejuvenation of old and senile orchards”. (Ed: Kalloo, G., Reddy, B.M.C., Gorakh Singh and B. Lal). Central Institute of Subtropical Horticulture. Rehmankhera, Lucknow-227 107, India. Pp. 36-40.

Thimmappaiah, Sundararaju, D. and Swamy, K.R.M., 2005. Experimental Manual on Cashew, NRC Cashew, Puttur, Karnataka. 104 pp.

11.6 Extension bulletins / pamphlets

Bhat P.S. and Venkattakumar , R. 2006. Geru beleyalli iluvari hechhisuva tantra vidanagalu (Technologies for enhancing yield in cashew) . Farmers’ View: Compilation during Annual Cashew Day, 14 March 2006. 5pp.

Yadukumar N. and Bhat P.S. 2005 Cashew Cultivation Practices (Kannada): National Research Centre for Cashew Extension Handout No.1 (Revised) 6pp.

Venkattakumar, R.,Yadukumar N., Bhat P.S. and Raviprasad, T.N. 2006 Cashew Cultivation Practices (English): National Research Centre for Cashew Extension Handout No.1 (Revised) 4pp.

12. LIST OF ONGOING RESEARCH PROJECTS

	Project No.	Particulars
I	**CROP IMPROVEMENT**	
	1.1	Collection, conservation, evaluation and cataloguing of cashew germplasm (MG Nayak, MG Bhat and PS Bhat)
	1.2	Varietal Improvement of Cashew (MG Nayak and MG Bhat)
	1.5	Micropropagation studies for clonal root stocks, somatic embryogenesis and rooting in cashew (Shirly R Anil and Thimmappaiah).
	Ad-hoc	Molecular characterization of cashew using RAPD and isozyme markers (Thimmappaiah and Shirly R Anil)
II	**CROP MANAGEMENT**	
	2.2(a)	Planting systems and spacing trials in cashew (N Yadukumar)
	2.2(b)	Fertilizer application and pruning trials in high density plantations (N. Yadukumar)
	2.3	Canopy management studies in cashew (MG Nayak and N Yadukumar)
	2.8	Efficacy of soil and water conservation with organic and inorganic manuring in cashew garden grown in slope areas (N Yadukumar and R Rejani)
III	**CROP PROTECTION**	
	3.6	Studies on determination of insecticide residues in cashew kernels(PS Bhat and TN Raviprasad).
	3.7	Studies on pheromones of tea mosquito bug *Helopeltis antonii* S. (PS Bhat and TN Raviprasad)
	3.8	Integrated pest management of cashew stem and root borer (CSRB) – Phase-II (TN Raviprasad and 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).
	3.11	Investigations on insect fauna associate with Cashewnut /kernels(TN Raviprasad and PS Bhat)
	Paid up Trial	Evaluation of newer insecticides against tea mosquito bug *Helopeltis antonii* Sig (P.S.Bhat).
IV	**POST HARVEST TECHNOLOGY**	
	4.8	Mineral composition of cashew kernel, testa, apple, pomace of released varieties(KV Nagaraja). Concluded in March 2006.
	4.9	Studies on preparation of nutraceuticals from cashew apple(KV Nagaraja).
	DBT	Nutraceuticals for healthy and speciality foods through biotechnology approaches (KV Nagaraja).

V	**TRANSFER OF TECHNOLOGY**	
	5.1	Transfer of technology programme in cashew (R. Venkattakumar, N.Yadukumar P.S. Bhat and M.G. Nayak)
	5.3	Socio- economic impact of cashew cultivation – An analysis (R Venkattakumar)
VI	**COMPUTER APPLICATION**	
	6.2	Computer application in cashew
	6.3	Database for cashew germplasm

13. IMPORTANT MEETINGS AND SIGNIFICANT DECISIONS

13.1 Research Advisory Committee

Dr. M.K.Nair Chairman, RAC, NRCC Shreeraj, Bedradka Post Via Kudlu Kasaragod – 671 124 Kerala	Chairman
Prof. D.P. Ray Dean Orissa University of Agriculture and Technology Bhubaneswar – 751 003 Orissa	Member
Dr. M.S. Kuruvinashetti Head, Department of Biotechnology College of Agriculture University of Agricultural Sciences Dharwad – 580 005	Member
Dr. G. Gajendran Professor of Entomology Anbil Dharmalingam Agricultural College and Research Institute Navalur Kuttapattu Tiruchy – 620 009,Tamil Nadu	Member
Dr. A.G. Appu Rao Head Protein Technology Division Central Food Technological Research Institute Mysore – 570 020	Member
Dr. K.V. Ramana Asst. Director General (PC) Indian Council of Agricultural Research Krishi Anusandhan Bhavan-II, Pusa Gate New Delhi 110 01	Member
Mr. G.K. Naidu No.4, 2nd Cross Street Jeth Nagar, R.A. Puram Chennai – 600 028	Member
Dr. P.M. Haldankar Professor and Head Department of Horticulture College of Agriculture Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth Dapoli – 415 712, Ratnagiri District Maharashtra	Non-Official Member
Dr. M.G. Bhat Director NRC-Cashew Puttur, Karnataka-574 202	Non-Official Member
Dr. N.Yadukumar, Principal Scientist (Agronomy) NRC-Cashew Puttur, Karnataka – 574 202	Member-Secretary

Composition of 4th RAC (from 7-10-2005 to 6-10-2008)
(Constituted vide ICAR Officer Order No. 13(8)/1995-IA-V dated 27-10-2005 of Under Secretary [Hort])
First meeting of fourth RAC (10th meeting) of NRCC was held on 19th and 20th April 2006 under the chairmanship of Dr. M.K.Nair . Drs. M.S. Kuruvinashetti, G. Gajendran , A.G. Appu Rao, K.V. Ramana , P.M. Haldankar, M.G.Bhat and scientists of centre participated in the meeting wherein progress made under research projects was discussed.

13.2 Institute Management Committee

Dr. MG Bhat, Director, NRCC, Puttur, - 574202, DK District, Karnataka	Chairman
Dr.KV.Ramana, Asst.Director General (PC), ICAR, Krishi Anusandhan Bhavan-II, New Delhi 110 012. Mobile: 09868627903	Member
Dr. K.R.Jayaram, Joint Director of Horticulture (PC), Department of Horticulture, Government of Karnataka, Lalbagh, Bangalore 560 004.	Member
Dr. TR Guruprasad, Associate Professor of Horticulture, Agricultural Research Station, Kapikad, Ullal 574 159, Mangalore, D.K. District.	Member
The Finance and Accounts Officer, Central Institute of Brackish Water Aquaculture, Chennai 600 008.	Member
Dr. B.M.C. Reddy, Project Coordinator (Tropical Fruit), Indian Institute of Horticultural Research, Hessaraghatta Lake Post, Bangalore 560089.	Member
Dr. N. Yadukumar, Principal Scientist, NRCC, Puttur - 574202, DK District, Karnataka	Member
Dr. D. Sundararaju, Principal Scientist (Ent), NRCC, Puttur - 574202, DK District, Karnataka	Member
Dr. MG Nayak, Principal Scientist (Hort), NRCC, Puttur. - 574202, DK District, Karnataka	Member
Sri G.K. Naidu, Kacharavedu Village, Alapakam Post, Nindra mandal, Chittoor District, Andhra Pradesh. Ph: 044-24938743	Member (Non-official)
Dr.P.M. Haldankar, Scientist and in-charge Horticulturist, Department of Horticulture, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth Dapoli 415 712, Ratnagiri District, Maharashtra.	Member (Non-official)
Sri K. Sanjeeva, Asst.Administrative Officer, NRCC, Puttur- 574202, DK District, Karnataka	Member- Secretary

The Institute Management Committee met twice on (19.8.2005 and 20.03.2006) and reviewed the progress of research project and ad-hoc projects. The equipments to be purchased and the works to be undertaken during the current year of X Plan period were finalized during the meetings.

13.3 Staff Research Council Meeting

The Eighteenth Annual Staff Research Council (SRC) was held on 7th and 8th June, 2005. There were different technical sessions - Crop Improvement chaired by Dr. K.R.M. Swamy, Head, Division of Vegetables, IIHR, Bangalore; Crop Management by Dr. B.P. Patil, ADR, RFRS, Vengurle; Crop Protection by Dr. B. Mallik, PC, AICRP on Acaralogy, UAS, Bangalore; Post Harvest Technology by Dr. S.N. Moorthy, Dept. of Crop Utilization, CTCRI, Thiruvananthapuram and Transfer of Technology by Dr. K.R. Jayaram, JDH, Dept. of Horticulture, Karnataka. Scientists from CPCRI, Kasaragod also attended the meeting. In the introductory remarks, Dr. M.G. Bhat, Director, NRCC, Puttur and Chairman of the SRC meeting briefed about the progress made in different research projects since last SRC meeting. The "Research Highlights-2004 - 05" was released by Dr. K.R.M. Swamy. The scientists of the centre presented progress made under different projects. Two new projects proposals were also approved during the meeting.

13.4 Institute Joint Staff Council (IJSC)

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

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

13.5 RAJBASHA (Enclosed)

14. PARTICIPATION IN SYMPOSIA / CONFERENCES / SEMINARS / MEETINGS

K.V.Nagaraja D.Sundararaju M.G.Nayak P.S.Bhat R.Venkattakumar	Capacity building ICAR-CITA Seminar-cum –Workshop on Globalized Economy at NAARM, Hyderabad	29-30 April 2005
T.N. Raviprasad	National Conference on "Intellectual Property Rights (IPR) and Management of Agricultural Research" jointly organized by the ICAR and Indian Potato Association, Shimla at National Agricultural Science Complex, New Delhi.	27-29 August 2005
P.S.Bhat T.N.Raviprasad	Group meeting on "Awareness and Action Plan for Pesticide Residues in Plantation Crops" at CPCRI, Kasaragod	20 September 2005
M.G.Bhat K.V.Nagaraja N.Yadukumar D.Sundararaju M.G.Nayak P.S.Bhat T.N. Raviprasad R.Venkattakumar	National Group Meeting of Scientists of AICRP on Cashew at Kerala Agricultural University, Vellanikkara, Thrissur, Kerala	28-30 November 2005
K.V.Nagaraja R.Venkattakumar	Brain Storming Session on " Strategic measures for making Indian Plantation Crops sector globally competitive" at CPCRI, Kasaragod.	31 January 2006
All Scientists	Seminar on "*Garcinia indica* (punarpuli), and its multi uses" at NRCC , Puttur	13 January 2006
M.G.Nayak	National Conference on "Agro Biodiversity" organized by National Biodiversity Authority at Chennai	12 - 15 February 2006
N.Yadukumar	National Seminar on "Resource Use Efficiency" at CPCRI, Kasaragod	25 March 2006

15. FARMERS DAY/KRISHIMELA/EXHIBITION/CAMPAIGNS

N. Yadukumar M.G. Nayak R. Venkattakumar	Thematic campaign on "Pruning and soil and water conservation measures in cashew", at Kaudichar village , Puttur	2 July 2005
N. Yadukumar R. Venkattakumar	Off campus training programme on "Cashew Production Technology" at Vorkady, Kasaragod	30 July 2005
M.G. Nayak R. Venkattakumar	Agri-Intex 2005 at CODISSIA trade fair complex, Coimbatore	11-16 August 2005
M.G. Nayak R. Venkattakumar	National Horticulture Kissan Mela cum Exhibition at IIHR, Bangalore	3-4 March 2006
All Scientists	Annual Cashew Day at NRCC,Puttur	14 March 2006
M.G. Nayak	Exhibition in the NEH Agri Expo organized at Dimapur, Nagaland	27 – 31 March 2006

16. DELEGATION / TRAINING

Melwyn Gregory Sequeira	Training on "IISR and RAPD marker application in plants" at Indian Institute of Spices Research (IISR), Calicut	25-28 April 2005
P.S. Bhat T.N. Raviprasad	"Chemoreception and behavioural responses in insect: Electroantennography and Olfactometry" at Project Directorate of Biological Control (PDBC), Bangalore .	18-23 July 2005
N. Yadukumar	MDP on "Assessment of agricultural research" organizations at NAARM, Hyderabad.	20-24 September 2005
T.N. Raviprasad	Training on "In vitro production of host insect and predators using artificial diets at Project Directorate of Biological Control, Bangalore	3-8 October 2005
M.G. Nayak	Winter school on " Intellectual Property Right Management of Genetic Resources – Tools and Dimensions" organized by Dept. Plant Breeding and Genetics, Hort. College (KAU), Thrissur, Kerala.	9 October - 29 November 2005
Melwyn Gregory Sequeira	Training on "Genomics and molecular modeling in plantation crops" at CPCRI, Kasaragod	15-20, November 2005
R. Venkattakumar	Winter School on " Appropriate Extension strategies for promotion of Organic Farming" at UAS, Dharwad	7-28 December, 2005
P.S. Bhat T.N. Raviprasad	Training on "Entomopathogenic Nematodes (EPN) for Insect Pest Control" held at Project Directorate of Biological Control (PDBC), Bangalore	20 February- 1 March, 2006.
M.G.Nayak	Training on "National Information Sharing Mechanism on Establishment of Global Plan of Action for PGRA in India", at NBPGR (RS) at Thrissur.	16 and 17 November, 2005.

17. Radio talk/ Interview / Video Programmes

17.1 TV Progrmme/Inter-view

M.G.Bhat	About NRCC, Puttur	In collaboration with Annadatha Kannada of E-TV, Hyderabad. TV programmes were produced and telecast in E-TV Kannada channel during April 2005 to March 2006
N.Yadukumar	• Establishment and management of cashew orchards • Inter and mixed cropping in cashew • Preparation of compost from cashew biomass	
M.G. Nayak	• Softwood grafting technique in cashew • Canopy management in cashew	
T.N. Raviprasad	Management of cashew stem and root borer	
P.S.Bhat	Management of tea mosquito bug	

17.2 Radio talk/ Inter-view

M.G. Bhat N. Yadukumar T.N. Raviprasad	Phone-in-Programme on Cashew Research and Development from All India Radio, Mangalore	2 June 2005
M.G. Bhat	Cashew Technology for Farmers – Geru Bele Hanada Hole (Baanuli Sarani) from All India Radio, Mangalore	16 July 2005
T.N. Raviprasad	Cashew stem borer menace and management	12 April 2006
M.G. Nayak	Vegetative propagation and nursery management in cashew	11 May 2006
M.G. Nayak	Training and pruning in cashew	11 August 2006
P.S. Bhat	Pest control in cashew crop broad cast from All India Radio, Mangalore.	26 August 2006

18. DISTINGUISHED VISITORS

Sri.S.Kumaraselvam Director –in –charge Aralam Farm Kannur District , Kerala	18 July 2005
Dr. J.V. Goud Ex- Vice Chancellor University of Agricultural Science, Dharwar , Karnataka	12 November 2005
Dr.S. D. Shikhamany Director IIHR, Bangalore , Karantaka	24 February 2006
Dr. H. Parswanath Deputy Commissioner Dakshina Kannada District Mangalore, Karanataka	2 March 2006
Dr. Gautam G. Kalloo Deputy Director General(Hort.) ICAR, New Delhi	26 March 2006

19. PERSONNEL

Managerial

Director Dr. M.G. Bhat

Scientific

Discipline	Scientist	Scientist (Sr.Scale)	Sr.Scientist	Pr.Scientist	Total (Incl. Vacant Posts)
Agricultural Engg. (ASPE)	D. Balasubramanian*	--	--	--	1
Agricultural Entomology	--	--	P.S. Bhat T.N.Raviprasad	D.Sundararaju	3
Agril.Extension		R. Venkattakumar (w.e.f. 14.06.2004)	--	--	1
Biochemistry (Pl.Sci.)	--	--		KV Nagaraja	1
Biotechnology	--	--	--	Thimmappaiah (Gen.& Cyto.)	1
Computer Application	PD.Sreekanth *	--	--	--	1
Genetics and Cytogenetics	Vacant		Vacant	--	2(2)
Horticulture	Vacant	--	Vacant-2 posts	M.G. Nayak (w.e.f. 29.09.2005)	4 (3)
Plant Physiology	Vacant	--	--	--	1 (1)
Soil Science	--	--	--	N Yadukumar (Agr.)	1
Soil and Water Cons. Engg.	R. Rejani	--	--	--	1
Soil Physics and water conservation	--	--	--	Vacant	1(1)
Total	6(3)	1	5(3)	6(1)	18 (7)

* On study leave for Ph.D.
Figures in the parantheses indicate no. of vacant posts.