CONTENTS

PREFACE

The progress made in different research projects pursued at this Centre is summarized in the Annual Report 1999-2000. Although the yield of cashew during last two years was poor due to adverse weather conditions, it is heartening to note that the crop yield during 1999-2000 is expected to be 5.2 lakh tonnes. In the research front, significant progress has been made in the areas of crop improvement, crop management, crop protection and transfer of technology during this year at NRCC.

Efforts are intensified to characterize germplasm collections and sixty accessions planted during 1989 were evaluated as per IPGRI descriptor after completion of 6 harvests bringing the number of accessions characterized so far to 213. In collaboration with Department of Horticulture, UAS, Bangalore thirtythree released varieties and a TMB tolerant accession have been DNA finger-printed. Similarly in collaboration with NRC for DNAFP nineteen accessions from germplasm have been DNA finger printed. In the network programme on collection of cashew germplasm from east and west coasts of India, fifteen diverse types have been collected for planting in NCGB/RCGB.

As hybrids have been found to be much superior to selections, a net working programme has been initiated with the parents identified from available germplasm collections from different Cashew Research Stations and over one thousand hybrid nuts have been produced for evaluation. The performance of nodal culture plants planted in the field is quite satisfactory. Micrografting technique has been standardized using in vitro raised seedlings as root stocks and aseptic nodal/shoot tip culture from mature tree source as micro scion.

In the crop management, results from this research centre have indicated the profitability of high density planting of cashew. Nutritional studies have indicated that application of 10 kg poultry manure/tree along with recommended dose of N, P and K is beneficial in realising higher yields. Studies on induction of dwarfing through chemical intervention have revealed reduction of plant height, canopy spread, and length of flowering and non-flowering laterals as compared to control due to soil application of paclobutrazol.

In crop protection, efforts to develop IPM against CSRB and TMB are underway. A method to estimate the age of field collected grubs of CSRB has been evolved which would help in initiating plant protection measures at appropriate time. Extracts/volatiles of cashew bark/frass in hexane elicited response from mated females of CSRB when tested by EAG indicating the presence of attractants. Phytosanitation coupled with post-infestation prophylaxis with fungal entomopathogen, *Metarhizium anisopliae* is found to be promising. Goa 11/6, a field tolerant accession against TMB has been planted in a number of on-farm trials for confirming the field escapism.

Studies on value addition in cashew have indicated the possibility of preparation of organoleptically acceptable flavoured cashew spread. Conditions for coating baby bits with cane sugar and honey have been standardized.

In transfer of technology, innovation has been made in conducting field campaigns on different themes in the farmers fields. Large number of farmers participated in Annual Cashew Day and during daylong deliberations, progressive farmers shared their experience on various aspects of cashew production, which would help as feed back in refining the technologies developed at this Research Centre.

I would like to place on record my sincere appreciation to all my colleagues who spared no efforts in pursuing the research projects for generating data presented in this Annual Report.

I am also grateful to the Editorial Committee for concisely presenting the achievements of the center during the year.

EVV Bhaskara Rao

Place : NRCC, Puttur
Date : 30 June 2000

(EVV. Bhaskara Rao)
Director

EXECUTIVE SUMMARY

There were fifteen ongoing research projects including 2 ad-hoc schemes of ICAR and one DBT scheme. Out of these, 5 projects each were in crop improvement and crop management, 2 each in crop protection and post harvest technology and one in transfer of technology. During the year one project under crop improvement was concluded.

A total of twentyseven diverse accessions of cashew were collected from Northern Tamil Nadu, Southern Kerala, Orissa, Karnataka and Goa for planting in NCGB which brings the total number of accessions planted so far in NCGB to 419. Sixty accessions were characterized as per IPGRI descriptors during the year. For the first time, in collaboration with NBPGR, 392 accessions were assigned the National Collection number. In collaboration with Department of Horticulture, UAS, Bangalore, thirtythree released varieties and a TMB tolerant accession have been DNA finger printed. Similarly another nineteen accessions from NCGB were DNA finger printed in collaboration with NRC for DNAFP.

In the germplasm evaluation, 13/5 Kodur (VTH 59/2) performed better with cumulative yield of 14.4 kg/tree after 9 harvests. Nineteen released varieties were evaluated for adherence of testa to kernels. Out of these, one variety (NRCC Sel-1) had loose, eleven had medium and 7 had light adherence. Processed kernels of eleven varieties were evaluated for the first time for physical and sensory characters by a panel of seventeen judges using Hedonic scale. Among these, kernels of NRCC Sel-1 was rated as the best. Promising hybrids such as H-46 and H 32/4 were planted in the selected farmers field and KCDC plantations at Bajathur for evaluating their performance. A network programme has been initiated with the parents identified from the available germplasm collection in different cashew research stations.

Incorporation of PVP and PVPP in tissue culture media resulted in increased

budding (75%) when nodal culture from mature plants were used. During year under report about 60 per cent of the tissue culture plants have flowered with normal floral and fruiting behaviour. Micrografting technique has been standardized using in vitro raised seedlings as root stock and aseptic nodal / shoot tip cultures from mature tree source as micro scion. The success per cent ranged between 50 and 100 when scions of more than 0.5 cm length were used. Soil moisture levels at deeper levels were low in high density plot (500 and 400 trees/ha) as compared to the recommended spacing plot (156 trees/ha). Cumulative yield from 7 harvests was 2627 kg/ha in high density plot (500 trees/ha) as compared to 721.5 kg/ha in recommended spacing plot (156 trees/ha). The net profit realized for first 9 years after planting in high density plot (500 trees/ha) was Rs. 43984/ha and Rs. 40204/ha under pruned and unpruned conditions respectively. In canopy management studies, after pruning cycles, plant height, number of flowering laterals/ m^2, number of non-flowering laterals/m^2, number of nuts/panicle, weight/nut and weight/apple differed significantly among the 4 varieties namely VRI-1, Ullal-1, VTH 30/4 and Sel-1. Nutritional studies have indicated that combination of 500 g N, 125 g each of P_2O_5 and K_2O and 10 kg poultry manure/tree was beneficial in getting higher yield. Studies have been initiated for devicing a model based on soil test and leaf analysis to develop package for targeted yield.

Studies have been initiated to induce dwarfing through chemical intervention. Soil application of paclobutrazol (8 g a.i./plant) reduced plant height, canopy spread, length of flowering and non-flowering laterals as compared to control.

A method for estimating the age of the field collected grubs of CSRB was evolved by measuring prothoracic shield width and body length which helped in estimating the period of egg laying. The maximum egg laying by adult beetle occurred during March-April. Post treatment prophylaxis trials against CSRB indicated that trees with less than 50 per cent infestation in collar region only responded

better for treatment with pesticides. Hexane was found to be the best solvent for collecting kairomones from cashew plant parts. Hexane extract of frass elicited maximum response from mated female beetles when tested with EAG.

TMB damage on Singapore cherry was noticed during monsoon. Egg parasitism of *Telenomus* sp. and Chaetostricha sp was noticed in all the months. Lamda cyhalothrin, acephate and carbosulfan showed maximum residual action against newly hatched nymphs. However, against late instar nymphs and adults of TMB, only lambda cyhalothrin exhibited maximum residual action.

Although iodine value did not change much during storage of cashew kernel oil at ambient temperature upto 4 months (18.3 to 18.9), peroxide value increased (9.0 to 29.6). Beyond 4 months, both iodine value (61.2) and peroxide value (67.1) increased sharply. Cashew milk and cashew spread were prepared from cashew baby bits. Sweetened and cocoa flavoured milk and sweetened spread flavoured with vanilla were the most preferred. Studies on coating of baby bits have indicated that ideal concentration for coating of baby bits with cane sugar was 70 per cent at 100°C.

Under transfer of technology, ten model cashew clonal gardens were raised during the year bringing the total number of demonstrations laid out so far to 78. Series of campaigns on soil and water conservation and plant protection were conducted in collaboration with KVK of CPCRI, Kasaragod, and a total of 598 farmers participated in these campaigns. Annual Cashew Day was conducted in which 150 farmers from Karnataka and Kerala participated. Progressive farmers shared their experience on different aspects of cashew cultivation in the seminar organized during the occasion. Besides training programme on vegetative propagation and cashew production technology, a training programme was arranged on utilization of cashew apple for farm women in collaboration with KVK of CPCRI, Kasaragod, Regional Centre, CFTRI, Mangalore and Department of Agriculture, Kerala.

INTRODUCTION

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

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

MANDATE

National Research Centre for Cashew is conceived to undertake mission oriented research projects with the mandate of evolving high yielding varieties of cashew with resistance / tolerance to pests such as tea mosquito, high protein, lysine and other desirable parameters; standardisation of agrotechniques for achieving higher production and productivity with sustainability in view, and transfer of technology to farmers and extension agencies on improved production techniques through training, demonstrations and extension literature.

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

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

ORGANIZATIONAL SET UP AND INFRASTRUCTURE

Headquarters

National Research Centre for Cashew is located with its headquarters at Puttur, Dakshina Kannada, Karnataka. The main campus is situated 5 KM away from Puttur town (45^0 N latitude, 75.4^0 E longitude and 90m MSL). Out of 69.02 ha of land contemplated for acquisition 68 ha have already been acquired for laying out field experiments at Kemminje. Besides the main campus housing Laboratory- cum-Administrative Block, Experimental Station at Shantigodu with an area of 80 ha which

is 13 KM away from the main campus also forms part of the Research Centre.

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

A well established Library at the Centre has got 850 reference volumes, 851 back volumes of journals and 755 reprints. Indian (38 Nos) and international (10) journals are also subscribed for the library. Photocopying, lamination and spiral binding facilities have been established at the library.

The headquarters of AICRP on Cashew is located at NRC Cashew, Puttur. It has 8 Coordinating Centres and a Sub-Centre located in Karnataka, Kerala and Maharashtra in the West Coast, Andhra Pradesh, Orissa, Tamil Nadu and West Bengal in the East Coast and in Madhya Pradesh which is a non traditional cashew growing area.

Website of the research Centre has been established.

Significant achievements of the centre:

- It has largest germplasm collection of cashew in the country (NCGB) with 419 accessions. NBPGR has assigned National collection numbers to 392 cashew accessions. Thirty three released varieties and a TMB tolerant accession have been finger printed in collaboration with Dept. of Horticulture, UAS, Bangalroe. Similarly nineteen accessions have been finger printed in collaboration with NRC for DNAPF.
- It has released two selections namely NRCC Sel-1 and NRCC Sel-2 which are high yielding and medium nut types for cultivation in Karnataka.
- In micropropagation, regeneration of cashew from the seedling explants (nodal cultures) has been standardised. Field planted micro propagated plants had higher root density and better morphological attributes when compared to control. Four species of VAM viz., *Scutellospora nigra, Glomus multicaule, G. microcarpum* and *G. australe* have been isolated from native cashew soils. Micrografting

technique for in vitro multiplication of cashew has been standardised and cashew plants raised by micro grafting have been potted.

- It also demonstrated the advantage of growing intercrops like pineapple profitably in cashew gardens.
- High density planting (625 plants/ha) was shown to be better than normal spaced planting (8m x 8m) with an yield increase of 2.5 times over control.
- Irrigating cashew at 60-80 litre of water per tree once in 4 days after initiation of flowering till fruit set and development coupled with the application of 750g : 187.5g : 187.5 g of NPK per tree led to significant higher yields.
- Leader shoot pruning combined with removal of dead wood has been found to have beneficial effect in of cashew.
- Soft-wood grafting method has been standardised for the commercial multiplication of high yielding varieties of cashew.
- Integrated Pest Management practices for the control of tea mosquito bug and cashew stem and root borer are being worked out. The rearing technique for cashew stem and root borer (CSRB) utilising host bark has been standardised to obtain test insects for further trials. Method for estimating the age of grubs of CSRB has been standardised by measuring prothoracic shield width and length. Volatiles and extracts in hexane from both healthy and frass material have been shown to elicit response from adult female beetles of CSRB by EAG studies.
- Biochemical quality of cashew varieties, biochemical changes during tea mosquito infestation, raw nut storage and causes for kernel rejects have been investigated. Functional properties of defatted cashew kernel flour have been compared with that of almond and soybean. Blending of cashew and soybean in the ratio of 1:1 improves the water absorption and emulsification capacity of cashew. Milk and spread could be prepared from cashew kernel baby bits. Sweetened and vanillin flavoured

cashew spread was the most preferred while salted spread is least preferred. Optimum coating of baby bits with honey and cane sugar occurs at 100°C at 70 per cent concentration.

- The centre has established very good linkage with farmers and officials of State Departments and Developmental agencies. It is monitoring 78 demonstration plots. It conducts training on cashew production technology, vegetative propagation of cashew, utilization of cashew apple and holds plant protection / soil and water conservation campaigns and field days for the benefit of farmers.
- It is serving as information centre on all aspects of cashew research and development.

Budget

The institute had an annual budget of Rs. 85.0 lakh under plan and Rs.101.5 lakh under non plan for the year 1999-2000. Besides, ICAR Revolving Fund Scheme had an outlay of Rs. 5.35 lakh and DCD Revolving Fund had Rs. 8.05 lakh. Two ad-hoc schemes had an allocation of Rs. 5.98 lakhs.

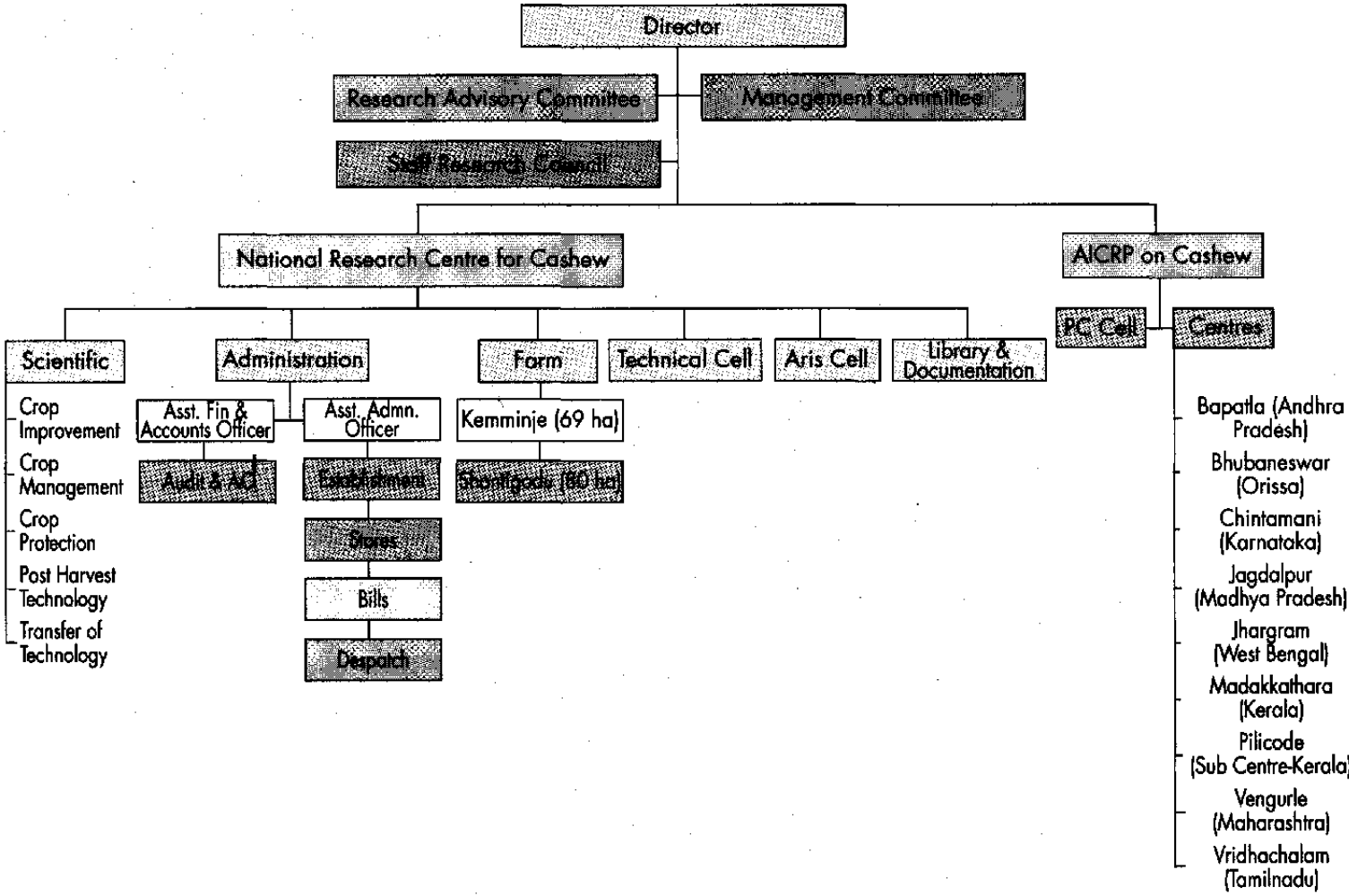
Staff Position as on 31.3.2000

	NON PLAN			PLAN			TOTAL		
Category	Sanctioned	Filled	Vacant	Sanctioned	Filled	Vacant	No. of Posts	No. filled	Vacant
Scientific	17	13	4	-	-	-	17	13	4
Technical	22	21	1	4	-	4	26	21	5
Administrative	14	14	-	1	-	1	15	14	1
Supporting	45	43	2	-	-	-	45	43	2
Total	98	91	7	5	-	5	103	91	12

Total Manpower

	Sanctioned	Filled	Vacant
Non Plan	98	91	7
Plan	5		5
Total	103	91	12

ORGANISATIONAL SETUP OF NRC-CASHEW



1. CROP IMPROVEMENT

1.1 Genetic resources of cashew

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

1.1.1 Germplasm collection and conservation

In collaboration with Centres of All India Coordinated Research Project on Cashew at Vridhachalam and Madakkathara, fifteen diverse types of cashew were collected from northern districts of Tamil Nadu (2) and southern districts of Kerala (13). These collections included the types with cluster bearing habit (upto 15 nuts/panicle), extended flowering duration, high shelling percentage (upto 33.9%), high yield (upto 59.3 Kg/tree), bold sized nuts (upto 14.5 g), big sized apple (upto 120 g) and cashew nut shell liquid free types. The clones of these have been produced for planting.

During the planting season of 1999, twentyseven clonal accessions collected from Orissa (2), Karnataka (10), Southern Tamil Nadu (5), Northern Kerala (9) and Goa (1), were planted in the National Cashew Gene Bank (NCGB) at Shantigodu, bringing the total number of accessions conserved in NCGB to 419 (Table 1.1).

Table 1.1: Details of germplasm accessions conserved in NCGB

State	Number of collections		
	Existing	Planted during 1999	Total
Karnataka	253	10	263
Andhra Pradesh	27	-	27
Tamil Nadu	10	5	15
Pondicherry	3	-	3
Goa	40	1	41
Maharashtra	21	-	21
Orissa	15	2	17
Kerala	9	9	18
West Bengal	14	-	14
Total	392	27	419

A total of fortyseven accessions (varieties / hybrids / genetic stocks) were supplied from NCGB to Centres of AICRP on Cashew / Research Institutes during the year 1999. Grafts of Goa 11/6 were also supplied to M/s. Sagar Nursery, Nanoda, Goa.

1.1.2 Germplasm evaluation

Sixty accessions (1989 planted) were evaluated and characterized after completion of 6 annual harvests as per IPGRI cashew descriptors, taking the total number of accessions characterized so far to 213. Of these, majority of the accessions had tall growth habit (67.1%), intermediate canopy spread (76.9%), extensive branching (89.2%), yellowish red coloured young leaves (68.0%), mid season flowering (70.4%), yellow coloured apples (61.5%), conical-obovate shaped apples (58.6%), kidney shaped nuts (100.0%), intermediate weight/nut (43.2%), intermediate attachment of nut to apple (41.8%), long duration of flowering (53.5%), medium ratio of apple to nut (73.2%), medium shelling percentage (60.1%), intermediate weight/ kernel (82.1%) and medium yield/plant (65.2%) (Table 1.2).

Table 1.2 : Details of 213 accessions characterised.

Field	Character name	Descriptor state		Total
10	Tree height	3	Dwarf (< 2.5 m)	3
		5	Semitall (2.5 - 4.0 m)	67
		7	Tall (> 4.0 m)	143
11	Canopy tree spread	3	Low (< 3.0 m)	3
		5	Intermediate (3.0 - 6.0 m)	164
		7	High (> 6.0 m)	46
16	Branching pattern	1	Extensive	190
		2	Intensive	23
19	Colour of young leaves	1	Red	46
		2	Yellow Red	145
		3	Green Yellow	21
		4	Purple	1
24	Leaf size	3	Small (< 60cm^2)	49
		5	Intermediate (60 - 120cm^2)	152
		7	Large (> 120 cm^2)	12
28	Season of flowering	3	Early (Nov - Dec)	47
		5	Mid (Dec - Jan)	150
		7	Late (Jan - Feb)	16

Table 1.2 : Details of 213 accessions characterised. (Continued)

Field	Character name		Descriptor state	Total
31	Mature cashew apple colour	1	Yellow	131
		2	Red	82
		3	Yellow Red	--
		4	Red Purple	--
32	Cashew apple shape	1	Cylindrical	51
		2	Conical - Obovate	125
		3	Round	26
		4	Pyriform	11
34	Nut shape	1	Kidney	213
		2	Oblong - ellipsoid	--
35	Nut weight	3	Low (< 5g)	40
		5	Intermediate (5 - 7 g)	92
		7	High (> 7 g)	81
43	Weight of cashew apple	3	Low (< 27g)	6
		5	Medium (27 - 52 g)	75
		7	High (> 52 g)	132
50	Attachment of nut to cashew apple	3	Loose	67
		5	Intermediate	89
		7	Tight	57
56	Relative position of suture and apex	1	Suture projection in front of apex	108
		2	Suture projection in line with apex	78
		3	Suture projection behind apex	27
60	Flowering duration	3	Short (< 60 days)	3
		5	Medium (60 - 90 days)	96
		7	Long (> 90 days)	114
61	Flowering intensity per m^2 (% of flowering laterals over total number of laterals)	3	Low (< 40%)	6
		5	Medium (6.0 - 12.0%)	86
		7	High (> 70%)	121
62	Apple to nut ratio	3	Low (< 6.0)	23
		5	Medium (6.0 - 12.0)	156
		7	High (> 12.0)	32
63	Shelling percentage	3	Low (< 18.0 %)	5
		5	Medium (18.0 - 28.0%)	128
		7	High (> 28.0 %)	80
64	Kernel weight	3	Low (< 1.2 g)	18
		5	Intermediate (1.2 - 2.5 g)	175
		7	High (2.5 g)	16
68	Cumulative yield per plant (6 annual harvests)	3	Low (> 9 kg)	73
		5	Medium (9 - 18 kg)	139
		7	High (> 18 kg)	1

All the sixty accessions (1989 planted) were screened against tea mosquito bug (TMB) by cage screening technique under field condition. All the accessions were found to be susceptible with maximum score of 4 in 0-4 scale.

Four accessions of *Anacardium occidentale*, namely AD 4.1, CCP 09, CCP 76 and CCP 1001, and one accession of *A. microcarpum* of Brazilian origin (seedlings planted during 1996) were evaluated for their growth parameters. The mean height of 3 year old plants was minimum (3.00 m) in AD 4.1, followed by CCP 09 (3.43 m), CCP 1001 (3.76 m) and CCP 76 (3.83 m). The mean height of 3 year old plants of *A. microcarpum* was 2.33 m. Nine accessions of seedling origin [Brazil (5), Mozambique (1) and indigenous (3)] which were planted during 1997 were evaluated for their growth. The mean plant height after 2 years of planting was minimum in Kodippady-2 (0.72 m), followed by Nampula 11-7 (1.06 m), followed by Cuddalore 1 (1.08 m) and CCP 96 (1.24 m).

'Kodippady - 2' a dwarf accession in NCGB

Juice from fully mature cashew apples collected from core collections in the NCGB was extracted and the flavonoids were estimated after clarification of cahew apple juice by addition of gelatin. The flavonoids content in the twelve accessions studied ranged from 0.114-2.278 mg/ml of clarified juice (Table 1.3). The accessions were also grouped into different groups based on the flavonoids content (Table 1.4). The accessions NRC 128, 145, 139 and 137 had least content of flavonoids and the accession NRC 120 had the highest content of flavonoids.

Table 1.3 : Flavonoids content of cashew apple of core collections.

Accessions (NRC)	Parentage	mg/ml of clarified juice
128	Nooji	0.114
145	VTH 150/2 = BLA 139-1	0.116
139	VTH 118/4 II = 11/44 Kerur	0.148
137	VTH 105/2 I	0.169
106	Balli-5	0.563
84	Goa Tr.No.37	0.670
47	VTH 191/17	0.809
99	VRI-3 = M 26/2	0.950
126	JJS	0.976
140	VTH 155 L	0.985
150	VTH 711/1	1.119
120	Nairoby	2.278

Table 1.4 : Grouping of accessions based on flavonoid content

Range (mg/ml of clarified juice)	Accession numbers (NRC)
> 0.1 < 0.2	128, 145, 139, 137
> 0.2 < 0.5	-
> 0.5 < 0.7	106, 84
> 0.7 < 1.0	47, 99, 126, 140
> 1.0 < 2.0	150
> 2.0	120

C/N ratio of shoots and leaves at different growth phases namely pre-flushing (Phase 1), 10 to 12 days after flushing (Phase 2), 20 to 25 after flushing (Phase 3) and 40 to 45 days after flushing (Phase 4) was determined and the results are presented in Fig.1.1. C/N ratio of the shoot from the vegetative lateral tend to decrease with flushing whereas, it does not change much in the leaf during flushing. In the case of flowering lateral C/N ratio of both shoot and leaves decrease initially followed by an increase. Decreased C/N ratio in young shoots of flowering laterals during post flushing and post flowering phases indicates the depletion of both carbohydrates and nitrogen which could have been metabolised for meeting the increased energy requirements.

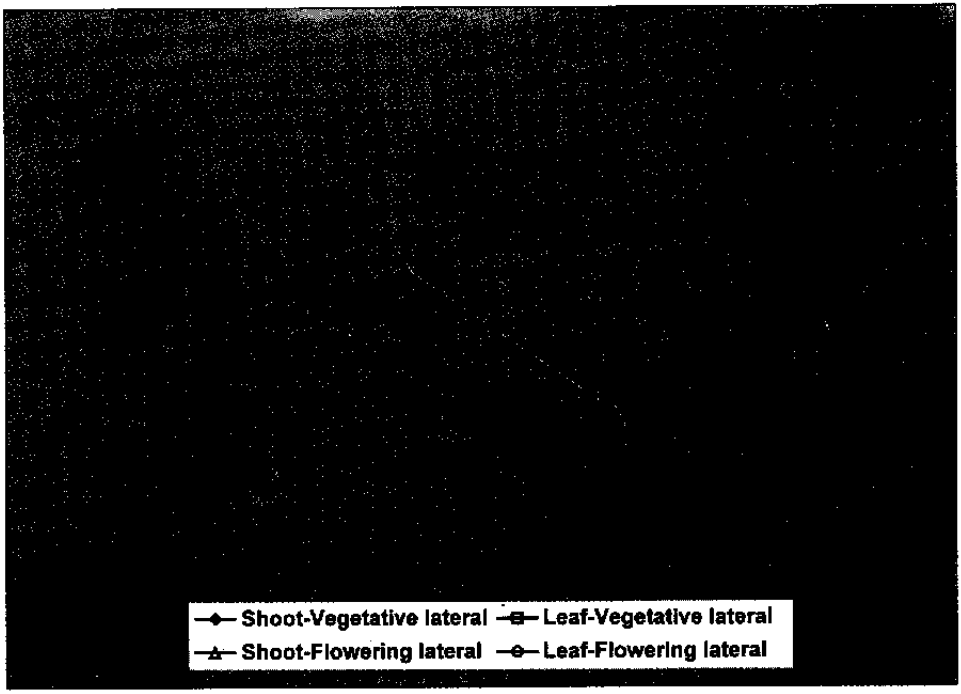


Fig. 1.1 : Changes in C/N ratio of shoots and leaves during different phases of shoot growth in cashew

Studies conducted on physiological maturity of nuts collected from accessions NRC 130, 99 and 124 at 30, 35, 40, 45, 50 days after anthesis and fully mature nuts have shown that kernel lipids and protein contents increased with increased maturity of nuts (Fig.1.2).

In order to safeguard our national interest in the field of plant genetic resources, indigenous collection numbers (IC Nos.) are being assigned to crop germplasm by National Buereau of Plant Genetic Resources (NBPGR), New Delhi. IC numbers have been obtained from NBPGR for 392 clonal accessions of cashew germplasm being conserved in the National Cashew Gene Bank (NCGB) at Puttur (IC No. 2,49,779 - 2,50,170). A booklet entitled "Cashew germplasm accessions (with IC No.) conserved in NCGB" (October 1999)

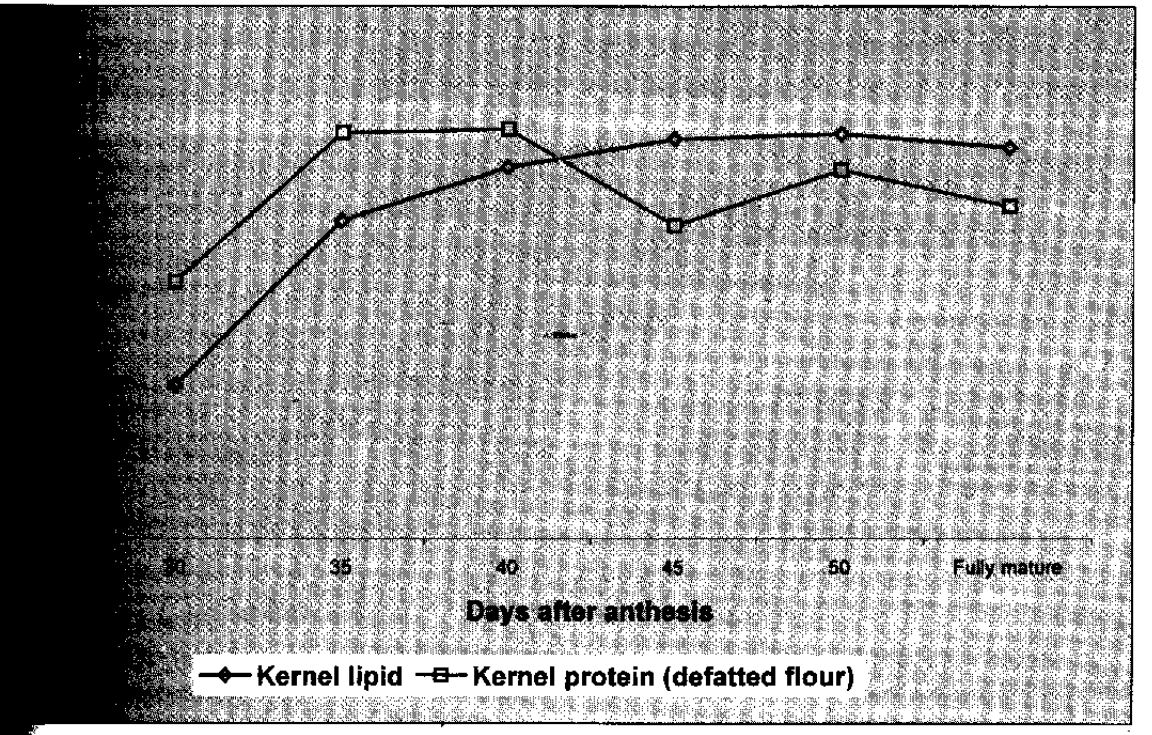


Fig. 1.2 : Kernel lipid and protein content in nuts of different physiological maturity

containing passport information along with IC Nos. for 392 clonal accessions of cashew has been prepared and a copy of the same has been supplied to AICRP on Cashew Centres, namely, Bapatla, Bhubaneswar, Chintamani, Jagdalpur, Jhargram, Madakkathara, Pilicode, Vengurle and Vridhachalam during the XIV Biennial Workshop of AICRP on Cashew held at Bhubaneswar from 28-30 October 1999.

The National Research Centre for Cashew has collaborative programme for DNA fingerprinting of cashew with Molecular Biology Lab, Horticulture Division, UAS, Bangalore under DST project and with NRC for DNA fingerprinting, NBPGR, New Delhi.

At UAS, Bangalore DNA extraction protocol from nearly matured dried leaves was standardized. Amplification of cashew DNA for RAPD analysis using operon random primers was standardized. All the released cashew varieties and hybrids (34) and a TMB tolerant accession (ME 4/4) were fingerprinted. The leaf samples of 33 cashew vareties and 153 cashew accessions were supplied from National Cashew Gene Bank (NCGB) of NRCC, Puttur. For mapping studies F1 hybrids (VRI-2 x VTH 711/4) was identified and selfed to obtain F2 population. Their studies with varieties using clus ter analysis with Jaccards and Pearson genetic similarity coefficients showed moderate level (70%) of genetic diversity in the 35 cultivars/ hybrids studied. By and large apart from some morphological traits, the individuals in a cluster shared a common geographical region. Among the different regions, the varieties and hybrids released from Kerala were much more diverse than other regions with least being among the varieties released from Maharashtra (Vengurle). The dendograms obtained using the two measures of similarity revealed moderate to high genetic diversity (Fig.1.3 and 1.4). Each and every cultivar could be identified using ten random operon primers. It was concluded that the cultivars grouped together also share some common morphological characters, which could be used to identify similar types. Cultivars NDR 2-1, K-22-1, Selection-1 and VRI-1 were placed distinct in both the dendograms.

At NRC for DNA fingerprinting, New Delhi, preliminary work on thirtyone cashew germplasm material collected from NCGB, NRCC, Puttur was done. DNA extraction protocol from fresh leaves using liquid N_2 was standardized. In nineteen accessions from which DNA was extracted, good positive amplification was observed using RAPD protocol. They used fifty primers all of which showed polymorphism.

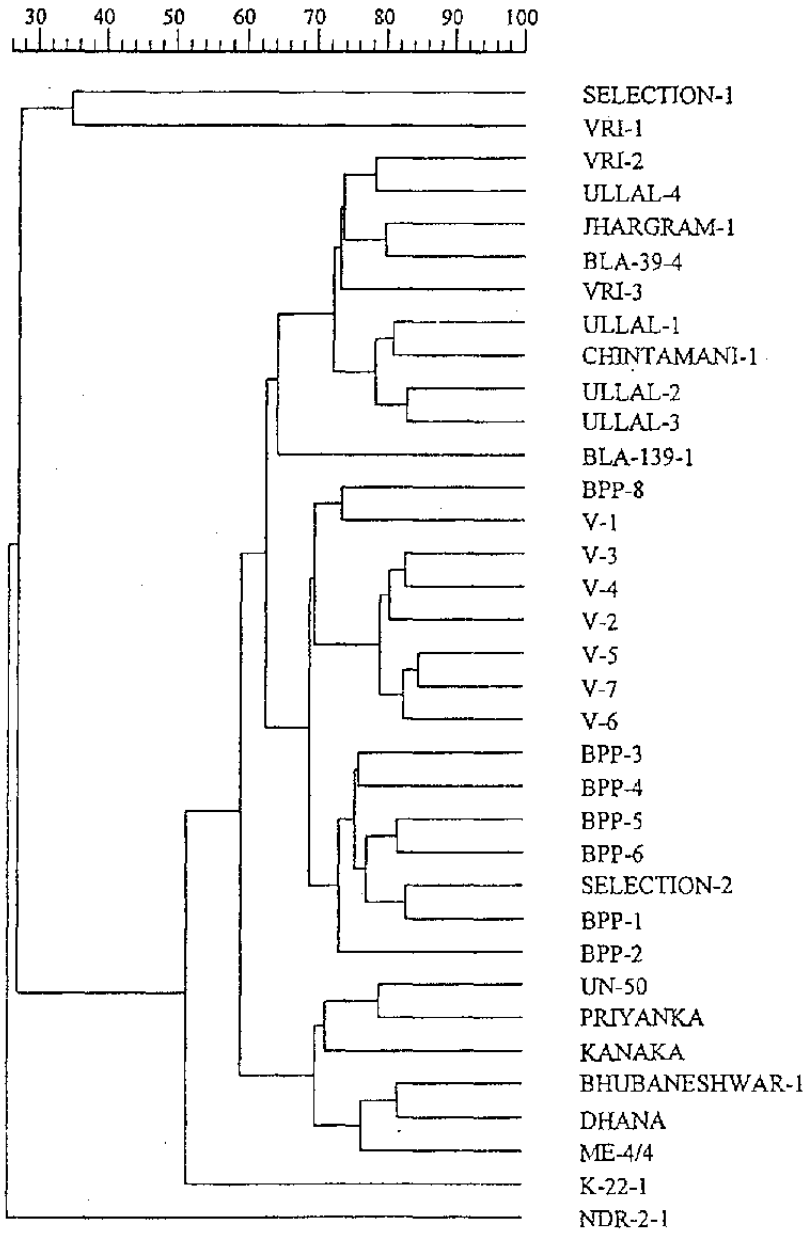


Fig. 1.3 : Associations among *Anacardium occidentale* genotypes revealed by UPGMA cluster analysis of Person genetic similarity coefficients calculated from RAPD data of 157 amplification products generated by 10 primers.

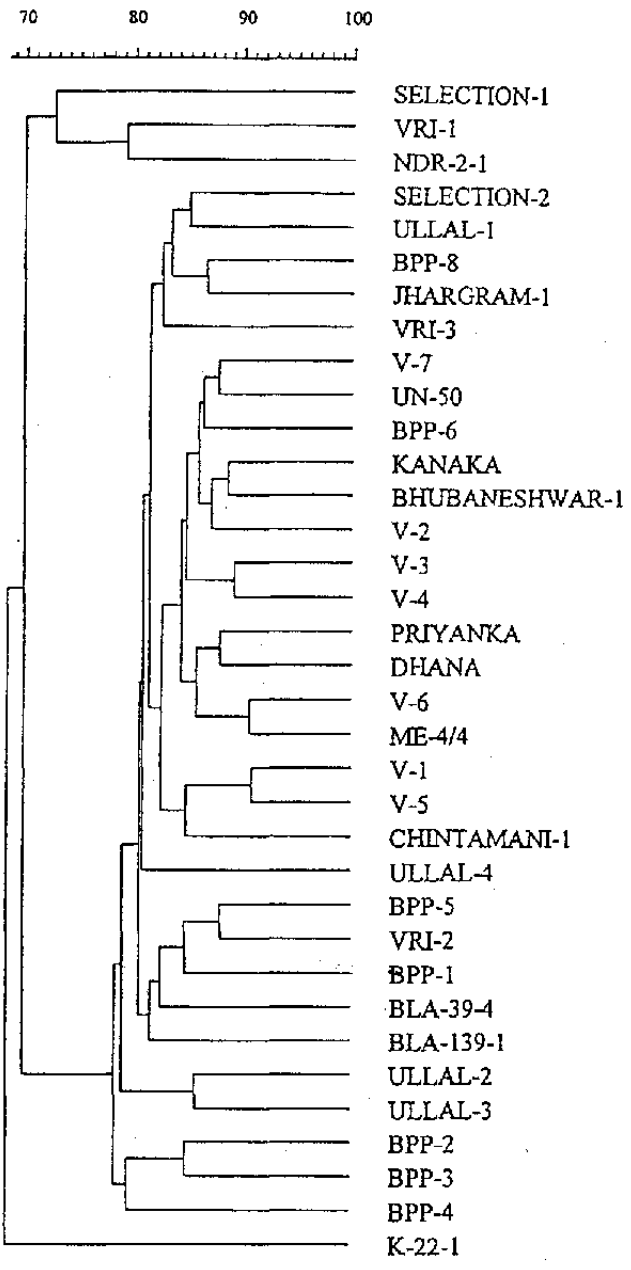


Fig. 1.4 : Associations among *Anacardium occidentale* genotypes revealed by UPGMA cluster analysis of Jaccard genetic similarity coefficients calculated from RAPD data of 157 amplification products generated by 10 primers.

1.2 Varietal improvement of cashew

Genetic improvement of cashew for yield and other important characters such as nut weight (>7g), kernel weight (>2g), shelling percentage (>28%) and quality of kernels was attempted by evaluating over one thousand hybrids from over forty cross combinations besides evaluating over sixty elite genotypes/varieties and selfs in 7 trials. Thirty two hybrid combinations are in the initial stage of evaluation.

1.2.1 Evaluation of elite germplasm accessions

Among the fourteen elite germplasm lines, performance of 13/5 Kodur (VTH 59/2) was the best for cumulative yield (14.4 kg/tree) for 9 harvests. The cumulative yield for the population was 11.5 kg/tree and that for VRI-2 was 10.8 kg/tree. The increase in cumulative yield of 13/5 Kodur over the population mean and VRI-2 were 25.7 per cent and 34.0 per cent respectively.

1.2.2 Evaluation of recommended varieties

Eleven recommended varieties in first trial and eight varieties in second trial were evaluated with VRI-2 as common check. The highest annual yield in eleventh harvest was recorded in BPP-4 (3.24 kg/tree) followed by VRI-2 (3.03 kg/tree) in the first trial. The highest cumulative yield of 15.22 kg/tree for eleven harvests was recorded in VRI-2 variety which was followed by BPP-4 (14.79 kg/tree).

In the second trial, the highest cumulative yield for 6 harvests was recorded in NDR 2-1 (4.75 kg/tree) followed by Ullal-2 (4.25 kg/tree) as compared to 3.47 kg/tree in VRI-2.

The duration of male phase (0-5% hermaphrodite flowers) and mixed phase (>5% hermaphrodite flowers) was determined in twenty varieties. Mixed phase was observed in all varieties while male phase was absent in BLA 139-1 and BLA 39-4 varieties. Mixed phase was shorter than male phase in 4 varieties (Ullal-1, Ullal-2, BPP-5 and NDR 2-1). The annual yield levels during the year under report were only intermediate in BLA 139-1 and BLA 39-4 varieties although the flowering phase was entirely mixed phase in those varieties.

Flowering lateral intensity and fruiting intensity per square metre of canopy and

estimated yield per square metre were determined for the last 2 years (1997-98 and 1998-99) for different varieties and the data were subjected to correlation and regression analysis. Both fruiting intensity and yield per square metre canopy had high positive correlation with estimated yield per tree in both years. Regression coefficients of estimated yield (Y) on fruiting intensity (X) in both years were on higher side (0.316 and 0.377) as compared to other regression coefficients (Table 1.5).

Table 1.5 : Correlation and regression coefficients of flowering and fruiting characters with estimated and actual yields in twenty varieties for 2 years (1997-98 and 1998-99).

a) Correlation coefficients	Characters	Correlation coefficient with			
		Estimated yield		Actual yield	
		1997-98	1998-99	1997-98	1998-99
	Flowering laterals	0.433	0.618	0.235	0.036
	Flowering lateral intensity	0.446	0.291	0.199	0.014
	Fruiting intensity	0.920	0.848	0.463	0.036
	Yield per sq. metre of canopy	0.913	0.850	0.460	-0.026
b) Regression coefficients	**Characters (X)**	**Regression coefficient (Y on X)**			
		Estimated yield (Y)		Actual yield (Y)	
		1997-98	1998-99	1997-98	1998-99
	Flowering laterals	0.110	0.301	0.040	0.015
	Flowering lateral intensity	0.022	0.018	0.007	0.001
	Fruiting intensity	0.316	0.377	0.107	0.014
	Yield per sq. metre of canopy	0.056	0.058	0.019	-0.002

The correlation coefficient between estimated and actual yield per tree was 0.549 in 1997-98 while it was 0.131 in 1998-99. Regression coefficient of actual yield per tree on estimated yield/tree was 0.370 kg/tree in 1997-98 while it was 0.114 kg/tree in 1998-99 (Table 1.6).

Table 1.6 : Relationship between Estimated Yield and Actual Yield in twenty varieties for 2 years (1997-98 and 1998-99).

	Character Pairs	Correlation coefficient	
		1997-98	1998-99
Correlation coefficient	Correlation: Actual yield and Estimated Yield	0.549	0.131
		Regression coefficient	
		1997-98	1998-99
Regression coefficient	Regression (Y On X) Actual yield (Y) on Estimated yield (X)	0.370	0.114

1.2.2 Status of adherence of testa to the kernel

Status of adherence of testa to the kernels was determined in nineteen varieties by recording the number of strokes required for removal of testa from the kernels. The varieties differed for this character and they were classified into 3 categories, namely, loose (<5.0 strokes), medium (5.0 - 7.5 strokes) and tight (> 7.5 strokes). Out of the nineteen varieties, one variety (NRCC Sel-1) had loose adherence, eleven had medium, while 7 had tight adherence of testa to the kernels (Table 1.7).

Table 1.7 : Status of adherence of testa to kernels in different varieties.

Status of adherence	Mean no. of strokes required	Name of varieties
Loose	< 5.0 strokes	NRCC Sel -1
Medium	5.0 - 7.5 strokes	K 22-1, BLA 39-4, BLA 139-1 BPP-3, BPP-5, BPP-6, H 3-17, Ullal-2, Vengurla-1, Vengurla-4, VRI-1
Tight	> 7.5 strokes	Ullal-1, BPP-1, BPP-2, BPP-4, NDR 2-1, NRCC Sel-2, VRI-2

1.2.3 Evaluation of hybrids/selfs

Hybrid No. 46 of cross VTH 36 (T.No. 56) X VTH 30 (A 18/4) showed superior performance for cumulative yield (20.27 kg/tree) for 10 harvests with a nut weight of 7.27g, kernel weight of 2.04 g and shelling percentage of 28.50. The increase in cumulative yield over check variety VRI 2 was 128 per cent. H 32/4, another hybrid, which had yielded a cumulative yield of 4.16 kg/tree for 4 harvests as against 2.30 kg/tree of VRI-2 in an replicated trial is also a promising hybrid. This hybrid has medium nut size of 7.0 g.

These promising hybrids namely H 46 and H 32/4 have been field planted in the selected farmers' field and Karnataka Cashew Development Corporation (KCDC) at Bajathur, Puttur Division for evaluating under field conditions.

1.2.4 Improvement of nut size in released varieties

Over one thousand hybrids from the crosses involving large number of released varieties and bold nut types are under evaluation. Grafts of hybrids produced in the previous year from the scions of detopped hybrid seedlings on a common root stock (VTH 174) have been field planted during current season for final evaluation with the idea of reducing the period for hybrid evaluation compared to the earlier method of field planting of the hybrid seedlings for preliminary evaluation and then final evaluation of selected hybrids in replicated trial through clonally propagated material. Hybrid No. 1354 of cross V5 x VTH 711/4 had superior performance both for annual yield in fifth harvest (4.20 kg/tree) and for cumulative yield for 5 harvests (10.35 kg/tree). The increase in nut weight of this hybrid over female parent was 84 per cent.

Hybridization work using skilled persons for producing large number of hybrids has been initiated during this season at NRCC Puttur pending approval by the Council under the ICAR Ad-hoc Scheme on "Network Programme on Hybridization in Cashew" with NRCC and other 5 centres of AICRP on Cashew as the operating locations for 3 years. Over one thousand hybrid nuts have been produced in seventyfive cross combinations under this scheme.

1.2.5 Primegenic dominance studies

Primegenic dominance or dominance hierarchy is the phenomenon because of which first formed fruits reduce the chances of fruit set from later opened flowers. Twenty varieties were studied for primegenic dominance in first set. Varieties differed for this phenomenon. In varieties BLA-139-1 and BPP-1 primegenic dominance was found to be operating. In three varieties, namely, BPP-2, BPP-5 and BPP-6, there was no primegenic dominance in the early stages of flowering while it appeared later. In 9 varieties (VRI-1, H-3-13, BLA 39-4, Ullal-2, VRI 2, K 22-1, BPP-3, NRCC Sel-1 and V-4), the effect of primegenic dominance was less.

Pollen germination studies

Pollen germination using pollen grains staminate and hermaphrodite flowers enty varieties was studied by hanging method using cavity slides. Pollen s were incubated in 25 per cent sucrose d medium at 28± 2°C for 2, 4 and 20 s. Maximum germination was noticed 20 hours of incubation. Pollen was ced after 20 hours of incubation. Pollen in from male flowers had higher mination capacity than that of maphrodite flowers in all varieties. Pollens from hermaphrodite flowers of thirteen varieties did not germinate at all, while those from the hermaphrodite flowers of 7 varieties showed lower germination, the range being from 4.32 per cent (in BPP-2) to 14.92 per cent (in BLA 139-1). The range for pollen germination from pollens of male flowers was 24.08 per cent (in BLA 39-4) to 50.67 per cent (in NDR-2-1). The highest pollen germination was observed in NRCC Sel-2 (51.83%), followed by BPP-2 (51.45%) and NDR-2-1 (50.67%) with pollen from both male and hermaphrodite flowers (Table 1.8).

ble 1.8: Percentage of pollen germination in 2 types of pollen source in ferent varieties.

Variety	Percentage of pollen germination after 20 h.		
	Male flower as pollen source	Hermaphrodite flower as pollen source	Total
NRCC Sel-1	35.85	0.00	35.85
NRCC Sel-2	39.71	12.12	51.83
V-1	41.33	0.00	41.33
V-4	49.16	0.00	49.16
VR-1	39.93	5.69	45.62
VR-2	25.94	8.24	34.18
BLA 139-1	26.03	14.92	40.95
BLA 39-4	24.08	9.34	33.42
Uliai-1	33.20	0.00	33.20
Uliai-2	43.79	0.00	43.79
BPP-1	42.00	4.86	46.86
BPP-2	47.13	4.32	51.45
BPP-3	40.86	0.00	40.86
BPP-4	46.82	0.00	46.82
BPP-5	49.37	0.00	49.37
BPP-6	47.76	0.00	47.76
HQ-13	29.46	0.00	29.46
HQ-17	29.05	0.00	29.05
NDR-2-1	50.67	0.00	50.67
K-22-1	40.77	0.00	40.77

1.2.7 Sensory evaluation of processed kernels

Processed kernels obtained from raw nuts procured from different origin were assessed for sensory characters based on mean cumulative hedonic scoring index. Among the kernels obtained from raw nuts of different origin, kernels from Turkewadi nuts (Maharashtra) (11.00 score) was ranked as the best followed by Goa nuts (11.23 score) and Puttur nuts (12.91 score). All these 3 samples were steam roasted. Kernels of Quillon nuts (drum roasted) was ranked the least (16.00 score).

1.3 Micropropagation

Studies on regeneration from explants of mature trees, induction of somatic embryogenesis, evaluation of micropropagated plants and standardization of micrografting have been pursued during the year under report.

1.3.1 Shoot-tip and nodal cultures of mature tree

In the micropropagation initiated with shoot-tip and nodal cultures from mature tree source, nodal cuttings were found to regenerate better than shoot-tips. Bud break in nodal cultures were found to be influenced by season of collection, type and source of explant. Bud break was high during dry months (Feb-Mar) and low during rainy season (Jun-Sept.). Cycles of grafting influenced response in cultures. Explants from second cycle grafts showed higher bud break (45.4%) than first cycle grafts (24.4%) in the same period of inoculation.

Among the four antibrowning substances incorporated in half-MS medium (0.2% activated charcoal, 0.1% PVP-360, 0.1% PVPP and 100 mg/l filter sterilized ascorbic acid), significant differences were observed in per cent bud break and number of leaves formed at the end period (6 weeks). Polyvinylpyorrolide (PVP-360) and polyvinylpolypyrrolidone (PVPP) showed higher response than others.

For axillary shoot-bud proliferation eleven media combinations involving thidiazuron (TDZ) (0.1, 0.5, 1.0 mg/l), 6-benzylaminopurine (BAP) (0.5, 1.0, 2.0 mg/l) alone and TDZ (0.1 mg/l) in combination with all the three levels of BAP (0.5, 1.0, 2.0 mg/l) were tested by incorporating in MS solid medium modified to contain half concentration of major nutrients, L-glutamine (400 mg/l), PVP-360 (0.1%) and gelled with 2.25 g/l phytagel.

Axillary shoot buds (1-9 buds/explant) were observed on transfer to basal medium. The best response (75%) was observed in the medium containing 0.1 mg/l TDZ with BAP (2 mg/l) with 1-5 buds/explant. However, there was no significant difference between the treatments for the average number of shoot buds per explant.

1.3.2 Induction of somatic embryogenesis

Maternal tissues like nucellus (bisected ovules) and leaf segments excised from in vitro source were cultured on a modified MS medium containing half the level of major nutrients, 6 per cent sucrose, 400 mg/l glutamine, 100 mg/l ascorbic acid and gelled with 2.25 g/l phytagel and supplemented with 2,4-D (0.5, 1.0, 2.0 mg/l) with 0.1 mg/l TDZ or 0.5 mg/l BAP. Callus was induced in nucellus on all the combinations but best response was in 1-2 mg/l 2,4-D. The nucleus callus was white initially and turned dark later. Proliferation of callus could be obtained on callus induction medium but embryogenesis was not observed when the calli was transferred to low concentration of 2,4-D (0.1 mg/l) and or culture on basal medium without any plant growth regulators. Similarly callus was induced in leaf segments only on medium with 2,4-D with TDZ and on 2,4-D with BAP, it was completely absent. Leaf callus was also white initially and turned dark on subculture. There was tendency of green pigmentation formation in some leaf callus cultures. Here also on medium with reduced level of 2,4-D and or on basal medium no embryogenesis could be observed.

1.3.3 Evaluation of micro propagated plants

During the year thirtysix rooted nodal cultures were subjected to hardening and thirtythree (94.4%) plants survived. About 60 per cent of the micropropagated plants planted in 1997 flowered during this year and some have borne fruits. Their flowering and fruiting behaviour appeared to be normal. During the year, another sixty micropropagated plants (twenty each) from H-4-7, VRI-2 and dwarf genotype were field planted along with their grafts following a closer spacing (5m x 5m).

Fruits from micropropagated plants

1.3.4 Micrografting

A micrografting technique in cashew has been standardized with an objective of achieving rejuvenation in mature tree explants. Root-stocks were raised in vitro by germinating mature seeds on a simple absorbent cotton medium presoaked with distilled water placed in screw cap bottles. Seedlings germinated in dark after 20-25 days were found suitable as root stock. In vitro grown shoots (shoot-tips and nodal cuttings) from mature tree formed the source of scion. Root-stock seedlings were decapitated leaving 1-2 cm of epicotyl after removing the cotyledons. An incision of 0.5-1.0 cm was made on cut end. The scion shoot was cut and prepared as a wedge (V shape). The wedge after pre-soaking in steril zea water was inserted into the vertical split made on epicotyl (shoot-tip grafting). Similarly side grafting was carried out by making incision on the hypocotyls at an angle of 45^0 and scion prepared as above was inserted from side. Both shoot-tip grafting and side grafting were successful with an overall success of 35-40 per cent (n=150). Grafting success was dependent on the length of scion (size) used. Grafting success increased (79.5%) with increase in size (5-15 mm) and reduced (8.5%) with decrease in size (3-5 mm). Liquid half Murashige and Skoog (1962) medium with 3 per cent sucrose was conducive for culturing micrografts. Micrografts after 10-12 weeks of culture were planted and have been established successfully in pots.

Micrografting in cashew

2. CROP MANAGEMENT

2.1 Planting systems and spacings

The study was initiated to understand the effect of systems of planting and spacing on growth and yield of cashew under pruned and unpruned conditions. The experiment was laid out following split plot design with three replications.

The main plot treatments included square systems (5m x 5m, 6.5m x 6.5m, 8.0m x 8.0m) and hedge system (5m x 4m, 6.5m x 4m, 8.0m x 4m) and with sub plot treatments being pruning and no pruning.

The tree height increased significantly (4.925 M) in high tree density plot (500 trees/ha) over recommended spacing plot (3.39 M - 156 trees/ha). Tree density had no effect on girth of stem. Effective canopy height was significantly more in low tree density plots (156, 236, 384 and 312 trees/ha) than high tree density plots (400 and 500 trees/ha). Ground coverage by crop canopy was significantly more in high tree density plots (100% in 500 trees/ha, 90.86% in 400 tress/ha). It also increased significantly more in unpruned trees than pruned trees (Table 2.1).

Light interception was significantly higher (93% and 87.5%) in high tree density plots (400 and 500 trees/ha) than low tree density plots (46% in 156 tress/ha, 64.5% in 312 trees/ha and 69.5% in 236 trees/ha.)

Sun exposed canopy area was maximum (9102, 7325 and 6304 m^2/ha) in treatment plots with 384, 312 and 236 trees/ha than in high tree density and low tree density plots (2548m^2 - 400 trees/ha, 2617m^2 - 500 trees/ha, 4064m^2 - 156 trees/ha) (Fig.2.1 a, b, c). Dry branches present due to natural shading in high tree density plot (8166 kg - 500 trees/ha, 7360 kg - 400 trees/ha) were maximum compared to low tree density plots (806 kg - 156 trees/ha, 1778 kg and 2376 kg - 312 and 236 trees/ha).

Cashew leaf deposit was 1.48 and 1.8 tonnes/ha in high tree density plots (400 and 500 trees/ha). The leaf deposit was 0.73 and 1.01 tonnes/ha respectively in plots with tree density of 156 and 312 trees/ha (Table 2.2).

Table 2.1 : Effect of tree density on tree height, canopy height and ground coverage.

Spacing (mxm)	Plant Density (Nos./ha)	Girth (cm)		Mean	Height (m)		Mean	Canopy height (m)		Mean	Ground coverage m^2/ha)		Mean
		Pruned	Unpruned		Pruned	Unpruned		Pruned	Unpruned		Pruned	Unpruned	
5x5	400	56.3	53.2	54.8	3.87	3.80	3.84	1.46	1.44	1.45	8569	9703	9136
6.5x6.5	236	50.0	43.7	46.8	3.23	2.81	3.02	1.92	1.98	1.95	6097	6342	6220
8x8	156	46.3	50.3	49.3	3.58	3.21	3.39	2.00	2.00	2.00	4835	5230	5018
5x4	500	48.0	54.3	51.2	4.72	5.13	4.93	1.45	1.36	1.40	10000	10000	10000
6.5x4	384	51.3	54.0	52.7	3.90	3.68	3.79	2.07	2.05	2.06	8495	8546	8520
8x4	312	55.0	51.0	53.0	3.83	3.45	3.67	2.13	2.26	2.19	7789	7524	7657
CD for density				NS			1.067			0.424			762.75
CD for pruning				NS			NS			NS			595.00
					T4>1,2,3,5 and 6			T2, 3, 5, 6>1, 4			1 and 4>2, 3, 5 and 6		

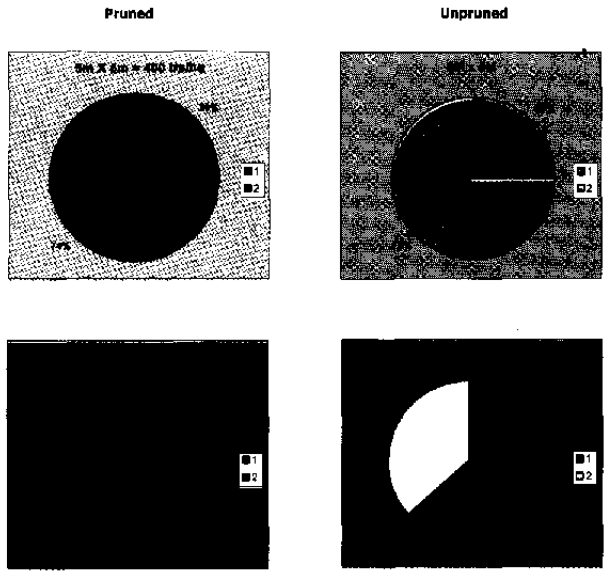


Fig. 2.1a: Effect of sun exposed canopy area (9 years after planting)

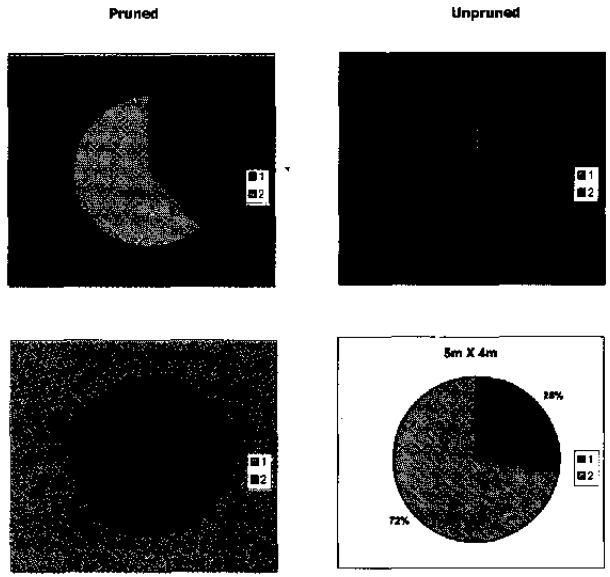


Fig. 2.1b: Effect of sun exposed canopy area (9 years after planting)

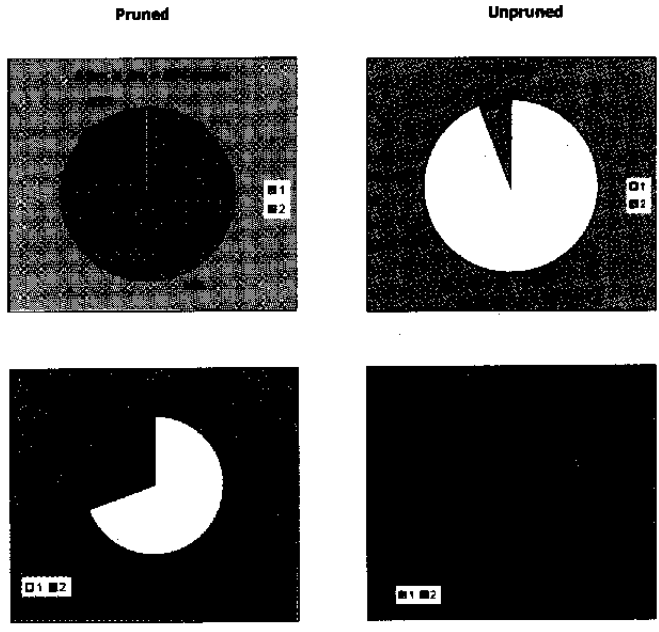


Fig. 2.1c: Effect of sun exposed canopy area (9 years after planting)

Nutrients present in leaf deposit was maximum in high tree density plots (18.48 kg/ha N 1.47 kg P_2O_5/ha and 4.88 kg K_2O/ha, in 400 trees/ha plot and 22.46 kg N/ha 1.44 kg P_2O_5/ha , 5.5 kg K_2O/ha in 500 trees/ha plot). It was 11.54 kg N/ha, 0.72 Kg P_2O_5 and 2.95 kg K_2O/ha in low tree density plot (156 trees/ha) (Table 2.2).

It was observed that organic matter, available nitrogen, phosphorous and potassium in soil upto 1 m depth was higher in high tree density plots (400 and 500 trees/ha) compared to low tree density plot (156 trees/ha). It was also observed that available P_2O_5 and K_2O contents were more at the basin of the tree than away from the basin in between trees (Table 2.3).

Weed biomass collected was significantly lower (0.44 and 0.41 tonne/ha in 400 and 500 trees/ha plots) in high tree density plots than that in low tree density plots (0.6 tonne/ha in 156 trees/ha, 0.91 tonne in 236 trees/ha and 1.07 tonne in 312 trees/ha plots).

Table 2.2 : Effect of tree density on cashew leaf litter and its nutrients.

Spacing (mxm)	Plant Density (Nos./ha)	Cashew leaf litter			Nutrients present in leaf deposit								
		Pruned	Unpruned	Mean	N Kg/ha		Mean	P_2O_5 (Kg/ha)		Mean	K_2O (Kg/ha)		Mean
					Pruned	Unpruned		Pruned	Unpruned		Pruned	Unpruned	
5x5	400	1.2	1.16	1.18	19.96	18.00	18.98	1.02	0.92	0.97	5.12	4.64	4.88
6.5x6.5	236	0.91	0.97	0.94	14.97	16.25	15.61	0.96	0.99	0.98	3.84	4.16	4.00
8x8	156	0.69	0.76	0.73	11.23	11.85	11.54	0.72	0.76	0.74	2.88	3.04	2.96
5x4	500	1.44	1.52	1.48	22.46	22.46	22.46	1.44	1.44	1.44	5.76	5.26	5.51
6.5x4	384	1.19	1.28	1.24	19.34	17.47	18.41	1.24	1.12	1.18	4.98	4.48	4.73
8x4	312	1.07	0.94	1.01	15.80	14.97	15.38	1.00	0.96	0.98	4.00	3.84	3.92

Table 2.3 : Effect of tree density on soil nutrient contents.

Spacing (mxm)	Plant Density (Nos./ha)	Between trees				1 m away from base of the trunk of the tree			
		OM (%)	Available N (Kg/ha)	Available P_2O_5 (Kg/ha)	Available K_2O (Kg/ha)	OM (%)	Available N (Kg/ha)	Available P_2O_5 (Kg/ha)	Available K_2O (Kg/ha)
5x5	400	3.87	172	0.50	79.2	4.12	183	9.05	178
6.5x6.5	236	3.47	154	0.64	119.3	2.38	106	4.09	89
8x8	156	2.47	109	0.78	81.3	2.19	98	3.51	90
5x4	500	4.54	202	0.48	100.5	3.90	174	5.28	131
6.5x4	384	3.89	173	0.57	92.00	2.53	113	3.03	116
8x4	312	2.95	131	0.37	69.00	2.52	112	3.57	76

The dry branches present due to shade effect were sixtyseven times higher (4.92 and 4.772tonne/ha) in high tree density plots (400 and 500 trees/ha) than low tree density plot (156 trees/ha). It was also observed that weed biomass collected was significantly lower (0.44 and 0.41 tonnes/ha in 400 and 500 trees/ha plots) in high tree density plots than that in low tree density plots (0.6 tonnes/ha, in 156 trees/ha, 0.91 tonne/ha in 236 trees/ha and 1.07 tonne in 312 trees/ha plots) (Table 2.4).

Significantly higher yield of 334 and 322 kg/ha 9 years after planting and 2238 and 2627 kg/ha from 7 harvests was observed in high tree density plots (400 and 500 trees/ha) compared to low tree density plots (120 and 722 kg in 156 trees/ha plot and 294 and 1358 kg in 236 trees/ha plot respectively (Table 2.5).

For the first 9 years after planting, maximum profit of Rs. 34810 and 30964 under both pruned and unpruned conditions

Table 2.4 : Effect of tree density on dry branches/ha and weed biomass collected (tonnes/ha)

Spacing (mxm)	Plant Density (Nos./ha)	Dry branches/ha (Tonne/ha)			Weed biomass collected (Tonne/ha)		
		Pruned	Unpruned	Mean	Pruned	Unpruned	Mean
5x5	400	4.920	7.360	6.14	0.42	0.46	0.44
6.5x6.5	236	1.864	2.376	2.12	1.57	1.45	1.51
8x8	156	0.790	0.806	0.798	1.48	1.41	1.45
5x4	500	4.775	8.170	6.47	0.42	0.39	0.41
6.5x4	384	2.240	2.342	2.29	1.15	1.26	1.21
8x4	312	1.830	1.778	1.81	1.10	1.20	1.15

In high tree density plots soil moisture was 3.35 to 3.53 per cent more at the top 0-30 cm depth than low tree density plot (156 trees/ha). At deeper layer (60-90 cm) 6 per cent less soil moisture was observed in plot with high tree density (400 and 500 trees/ha) compared to low tree density plot (156 trees/ha).

in 400 trees/ha plot was realized. Similarly in plots with 500 trees/ha an amount of Rs. 43984 and 40204 was realized under pruned and unpruned conditions respectively. Minimum profit of Rs. 9025 and 5393 in plots with 156 trees/ha was realized under pruned and unpruned condition respectively (Table 2.6).

Table 2.5 : Effect of spacing and system of planting on yield under pruned and unpruned conditions (9 years after planting)

Spacing (mxm)	Plant Density (Nos./ha)	Yield / plant (kg)		Yield/ha (kg) 6th harvest			Cumulative yield (kg/ha)		
		Pruned	Unpruned	Pruned	Unpruned	Mean	Pruned	Unpruned	Mean
Square									
5x5	400	0.845	0.823	338	329.7	334	2268	2207	2238
6.5x6.5	236	1.098	1.389	259	327.7	294	1384	1332	1358
8x8	156	0.835	0.697	130.3	108.7	120	819	624	722
Hedge									
5x4	500	0.727	0.564	363.3	282.0	322	2735.3	2518	2627
6.5x4	384	0.726	0.579	278.7	222.3	251	1814.7	1683	1749
8x4	312	0.624	0.576	194.7	179.7	187	1611.7	1419	1515

Table 2.6 : Economics of spacing trial treatment plots.

Spacing (mxm)	Plant Density (Nos./ha)	Cost of cultivation/ha		Income/ha		Profit/ha	
		Pruned	Unpruned	Pruned	Unpruned	Pruned	Unpruned
5x5	400	35932	34707	70742	65671	34810	30964
6.5x6.5	236	27907	26862	47947	46925	20040	20043
8x8	156	19699	19059	28724	24452	9025	5393
5x4	500	43388	42163	87372	82467	43984	40304
6.5x4	384	37849	36824	60724	54722	22875	17898
8x4	312	30721	29686	54346	49481	23625	19795

2.2 Canopy management studies in cashew

Canopy management studies have been initiated with an objective of studying the effect of pruning on canopy containment, flushing and flowering, and yield of cashew. A field trial on canopy management of four different cashew varieties viz., VRI-1, Ullal-1, VTH 30/4 and NRCC Sel-1 having varied flushing time and branching habit was laid out during the year 1992-93 in Factorial Radomised Block Design with three replications. Different pruning treatments viz., yearly pruning (leader shoot + general pruning), alternate year pruning (leader shoot + general pruning) and shape pruning (general pruning) were imposed every year between July and August since 1995. A control was maintained without pruning treatments. The third cycle of pruning was imposed during the first week of August 1999.

2.2.1 Effect on plant growth

Growth of trees with respect to height and spread of canopy remained similar to control in yearly and alternate or shape pruned trees (Table 2.7). Number of flowering laterals were drastically reduced in yearly and alternate year pruned trees compared to shape pruned and control trees while the number of non-flowering laterals were more in yearly and alternate year pruned trees. Length of flowering and non-flowering laterals was considerably reduced in yearly pruned trees. The leaf biomass dropped was upto the tune of 10.48 kg annually in NRCC Sel-1 trees and the pruning treatment did not influence the quantity of leaf fall. The light interception pattern is similar in all the pruning treatments as well in four varieties tested.

2.2.2 Effect on yield

The cumulative yield of first 4 annual harvests remained similar irrespective of pruning treatments (Table 2.8). Number of nuts matured per panicle was significantly low in yearly pruned trees (4.00) compared to other treatments. Though there was significant differences with respect to nut weight, the difference was negligible, but the weight of apples was less in yearly pruned trees compared to control or other treatments. Multivariate as well as univariate tests conducted with the yield data revealed that there is no significant difference with the incremental yield in different treatments.

Table 2.7 : Effect of pruning on growth of different cashew varieties.

Treatment	Plant height (m)	Canopy spread (m^2)	No. of laterals/m^2 area		Length of laterals (cm)		Total leaf biomass dropped (kg)	Leaf biomass removed by means of pruning (kg)
			Flowering	Non - flowering	Flowering	Non - flowering		
A. Varieties								
VRI - 1	4.53	6.26	16.83	14.75	33.67	16.58	7.92	1.51
Ullal - 1	5.48	6.50	13.42	14.42	34.75	18.42	7.46	1.09
VTH 30/4	4.34	6.35	12.58	13.67	34.92	17.17	7.53	1.11
Sel - 1	5.71	6.75	12.08	12.92	35.17	22.17	10.48	1.96
CD for A	NS	NS	1.13	NS	NS	3.21	NS	NS
B. Pruning treatments								
No pruning (Control)	5.14	7.00	16.08	13.42	36.58	22.33	8.44	0.00
Yearly pruning	5.01	6.55	12.00	15.58	31.50	15.58	8.33	1.58
Alternate Year Pruning	5.01	3.35	12.33	14.75	36.83	18.17	8.27	2.25
Shape pruning	4.91	6.48	14.50	12.00	33.58	18.42	8.34	1.74
CD for B	NS	NS	NS	3.35	5.15	3.01	NS	0.45
CD for AB	NS	NS	NS	NS	NS	6.02	NS	0.89

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

Table 2.8: Effect of pruning on yield of cashew.

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

2.3 Integrated nutrient management for sustainable production of cashew

In order to develop suitable combinations of organic and inorganic manures for increasing the yield of cashew and to explore the possibilities of composting cashew wastes, an experiment was laid out in 1999 with revised treatments. The details of the treatments are as follows:

RBD with four replications

Treatments

i) 100% N in the form of inorganic manure.

ii) 75% N in the form of inorganic manure and remaining 25% in the form of cashew waste compost.

iii) 50% N in the form of inorganic manure and remaining 50% in the form of cashew waste compost.

iv) 25% N in the form of inorganic manure and remaining 75% N in the form of cashew waste compost.

v) 100% N in the form of organic manure only.

The remaining recommended doses of P and K are applied in the form of inorganic manure.

Each treatment plot has 8 treatment plants.

Spacing : 7m x 7m

Total area covered : 2.4 ha.

Cashew waste composts were prepared by adopting Japanese method. Cashew wastes like leaf litter, dried leaves, cashew apples were spread layer wise above the ground in the dry month towards the end of cashew nut harvest season (May). Japanese compost chamber consists of frame work with 5 m length, 1 m width and 1.5 m height. After spreading cashew waste layer wise and over each layer 10 per cent of the total weight of waste materials, cow dung slurry and thin layer of soil were spread.

Like wise 4 to 5 layers were prepared one above the other. Sufficient moisture (50%) was maintained by sprinkling water frequently during dry period. With the onset of monsoon the Japanese chamber was covered with coconut leaves so that excess water is allowed to drain away. The compost was turned up side down twice during rainy season to allow uniform decomposition. Towards the end of the rainy season (5 to 6 months period) the compost was analysed and after ascertaining nutrient contents the dosage as per the treatments was given in the field of the above experiment. The nutrient contents of cashew waste compost are as follows (Table 2.9).

Table 2.9: Nutrient content of cashew waste.

Nutrient	Per cent / PPM
N	1.59 (%)
P	0.53 (%)
K	0.33 (%)
Ca	0.94 (%)
Mg	0.56 (%)
Zn	0.60 (ppm)
Mn	74.50 (ppm)
Cu	4.02 (ppm)
Fe	86.00 (ppm)

Organic matter and available N contents were significantly more in plots receiving 75 to 100 per cent N in the form of organic manure only when compared to 50, 25 and no N in the form of organic manure and remaining in the form of inorganic manures. Available N was low in all the other treatments. Available P_2O_5 contents did not vary significantly due to different manurial treatments. Potassium level was medium in treatments receiving (i) 25% N in the form of inorganic manure and remaining in the form of organic manure (ii) 100% N in the form of organic manure only. In all the other treatments potassium levels were low (Table 2.10).

Table 2.10: Effect of manurial treatments on soil nutrient contents.

Treatments	Depth (cm)	Organic Matter (%)	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)
100% N in the form of fertilizers (inorganic manures)	0-30	1.71	76.08	8.66	108.33
	30-60	1.22	54.21	4.89	75.00
	60-90	0.78	34.72	0.75	64.33
75% N in the form of fertilizers remaining in the form of OM (cashew waste compost)	0-30	2.16	96.37	9.03	122.67
	30-60	1.58	70.50	4.47	95.00
	60-90	1.13	50.45	0.66	75.67
50% N in the form of fertilizers remaining in the form of OM (cashew waste compost)	0-30	2.43	108.3	9.64	111.64
	30-60	1.80	80.29	4.90	82.97
	60-90	0.95	42.42	0.66	74.67
25% N in the form of fertilizers remaining in the form of OM	0-30	3.13	139.3	9.64	152.50
	30-60	2.06	91.55	5.17	109.87
	60-90	1.10	48.97	0.60	57.67
100% N in the form of OM only	0-30	3.50	155.8	9.27	138.17
	30-60	2.10	93.35	5.73	102.20
	60-90	1.05	45.64	0.62	58.00
CD for treatment		0.641	28.15	1.38	19.75
CD for depths		0.47	20.85	0.89	13.24

In an observational trial conducted on organic and inorganic manures, application of full dose of recommended NPK @500:125:125 g/tree and 10 kg poultry manure resulted in 300 per cent higher yield over control plot receiving no fertilizers and poultry manure (Table 2.11). With fertilizer application alone, the yield was 150 per cent of control plot and only with poultry manure application the yield realized was 120 per cent of control (Table 2.11). Thus application of recommended dose of fertilizer and 10 kg of poultry manure is beneficial in realizing higher yield.

Table 2.11: Effect of manures on the yield of cashew (2 years mean)

Treatments	Mean of 2 years yield (kg/tree)		Mean yield (kg/tree)	% of control
	VRI - 1	VRI - 2		
Full dose of NPK @ 500:125:125 g/tree	1.45	3.62	2.54	191
Poultry manure @ 20 kg/tree (Full dose)	1.29	1.93	1.61	121
Full dose of NPK @ 500:125:125 g/tree plus half dose of poultry manure @ 10 kg/tree	1.47	6.70	4.08	308
Half dose of NPK @ 250:62.5:62.5 g/tree plus half dose of poultry manure @ 10 kg/tree	2.87	3.90	3.39	255
No NPK and no poultry manure (Control)	1.55	1.41	1.33	100
Mean	1.726	3.512		
CD for Main plot			0.759	
CD for Sub plot			0.575	
CD for Interaction			1.284	

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

An experiment has been laid out to evaluate different soil and water conservation techniques coupled with organic and inorganic manuring. The experiment consisted of 5 main plot treatments and 3 sub plot treatments and has been laid out in split plot design with

three replications. The details of the treatments are as follows:

Main plot treatments (4)

1. Individual tree terracing with catch pit.
2. Individual tree terracing with crescent bunding.
3. Staggerred trenches between two rows of cashew.
4. Control plot without any soil conservation technique.

Sub plot treatments

1. Application of recommended doses of fertilizers only (750 g N : 150 g each of P_2O_5 and K_2O/tree/year).
2. Application of recommended doses of fertilisers + organic manure (10 kg poultry manure).
3. Application of organic manure only (20 kg poultry manure).

Nutrient contents in soil before imposing treatments were determined. The organic matter, available N and P_2O_5 were low. Available K_2O was in the medium range (Table 2.12).

Table 2.12: Nutrient contents in soil before imposing the treatment.

Soil nutrient levels	Depth (cm)			Nutrient status
	0-30	30-60	60-90	
Organic matter (%)	1.46	1.09	0.45	Low
Available N (kg/ha)	65.00	48.66	20.00	Low
Available P_2O_5 (Kg/ha)	10.20	5.63	2.00	Low
Available K_2O (kg/ha)	158.40	105.00	52.00	Medium

2.5 Root stock studies

Root stock studies are contemplated to understand the role of root stocks on canopy growth and to induce dwarfing in root stocks through chemical intervention.

2.5.1 Observational trial on root stocks

An observational trial was planted during 1996 with air layers of root stocks (Selection-1, VTH 762/2, VTH 762/4, S 11/1, S 11/2) to study the influence of root stocks (tall and semi-tall) on the growth of scion variety (Selection-1). In situ grafting with scions of Selection-1 was also made on these root stocks during 1997. The plants of Selection-1 were vigorous with higher

mean plant height, stem girth and canopy spread as compared to the less vigorous / semi tall root stocks. Growth of the scion variety (Sel-1) was vigorous irrespective of the root stocks (Sel-1, VTH 762/2, VTH 762/4, S 11/1, S 11/2) (Fig.2.2 and 2.3).

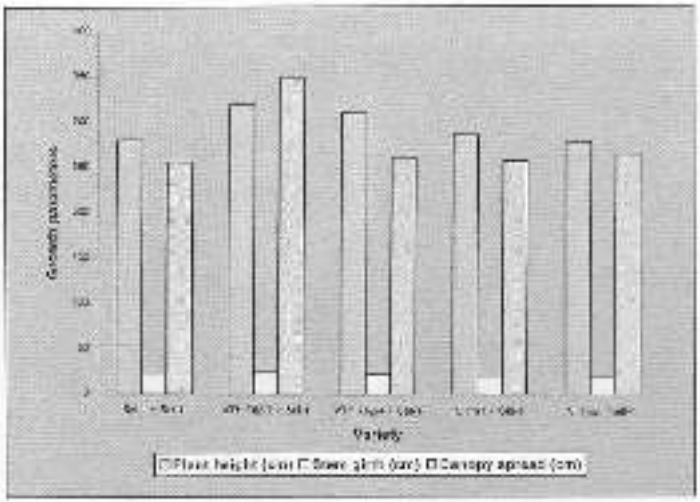


Fig. 2.2 : Growth parameters of 2 year old *in situ* grafts of Sel - 1 on different root stocks

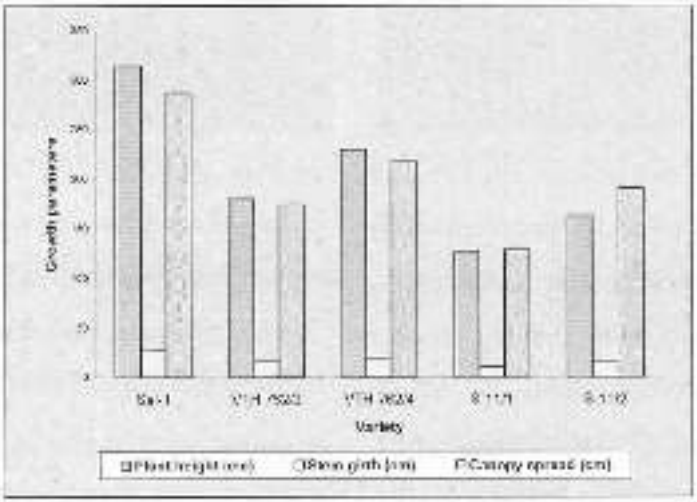


Fig. 2.3 : Growth parameters of 3 year old air layers of different root stocks

2.5.2 Induction of dwarfing through chemical intervention

In order to study the effect of paclobutrazol (cultar 25% EC ; ZENECA-ICI Agrochemicals Ltd., Chennai), an antigibberellin biosynthate, on growth and fruiting in cashew, two separate experiments were initiated during September 1999 on 10 year old plants (soil application on Vengurla-3 and foliar application on VTH 30/4) in the scion bank (RBD with split plots ; 4 replications).

The soil application of paclobutrazol (0, 2, 4, 6 and 8 g a.i./plant) was done in the month of September (near the collar region and in circular trench mid way between trunk and drip line). Each dosage of paclobutrazol was dissolved in 5 litres of water and applied in 15 cm deep trench and covered with soil. Observations were recorded on increase in plant height, increase in canopy spread, number of flowering and non-flowering laterals/m^2, length of flowering lateral, sex ratio, number of nuts/panicle and nut yield/plant. Significant differences among different concentration of paclobutrazol (soil application) were observed for increase in plant height, increase in canopy spread, length of flowering laterals, length of non-flowering laterals and number of nuts/panicle. There were no significant differences between collar drenching and circular ring method of application for these characters. Soil application of 8 g a.i. PBZ/plant was found to be effective in reducing the plant height (72%), canopy spread (65%), length of flowering lateral (64%), length of non-flowering lateral (75%) as compared to control. This has also increased the number of nuts/panicle (114%).

The soil application of paclobutrazol on 3 year old plants of "Kanaka" in the scion bank was also done (8 g a.i./plant ; and control) in the first week of September 1999. The paclobutrazol was dissolved in 2 litres of water and applied in 15 cm deep trench and covered with soil. Soil application of paclobutrazol (8 g a.i./plant) reduced plant height, canopy spread, number of

non-flowering laterals/m^2, length of lateral shoots (both flowering and non-flowering) and sex ratio and increased number of flushes/m^2, number of flowering laterals/

Three year old "Kanaka"

m^2, and number of nuts/panicle. In the treated plants rosetting of leaves and panicles emerging from the apical buds of previous season's growth were observed.

The foliar application of paclobutrazol (0, 100, 200, 300 and 400 ppm) was done during pre-flushing (September) and post flushing (November) season. Each dosage of paclobutrazol was sprayed on each plant to run off (approx. 2 litres/plant). Microwet (surfactant) @ 1 ml/litre of spray solution

Paclobutrazol treated 3 year old "Kanaka"

was also added. Observations were recorded on increase in plant height and canopy spread, number of flowering and non-flowering laterals/m^2, number of flushes/m^2, length of flowering lateral, sex ratio, number of nuts/panicle and nut yield/plant. Significant differences among

different rates of paclobutrazol were observed only for length of flowering and non-flowering laterals.

There were no significant differences between applications during September and November. The foliar application of paclobutrazol on 3 year old plants of "Kanaka" in the scion bank was also done (0, 400, 800 ppm) in the first week of September 1999 (pre-flushing) and November 1999 (post flushing). Each dosage of paclobutrazol was sprayed on each plant to run off (approx. 500 ml/plant). Microwet @ 1 ml/litre was also added. Foliar application of paclobutrazol (400 ppm and 800 ppm) has reduced plant height, canopy spread and increased number of nuts/panicle. However, foliar application of PBZ was not effective as compared to soil application.

2.5.3 Observational trial on chlormequat chloride

An observational trial on foliar application of chlormequat chloride (0, 500, 1000, 1500, 2000 and 2500 ppm) was initiated during September 1999 on 3 year old "Kanaka" plants, to study the effect of chlormequat chloride (Lihocin 50 AS, BASF India Limited, Mumbai) on growth and fruiting in cashew. Each dosage of chlormequat chloride was sprayed on each plant to run off (approx. 500 ml/plant) during pre-flushing (September) and post flushing (November) stages. Microwet (surfactant) @ 1 ml/litre was also added to the spray solution. Foliar application of chlormequat chloride has reduced plant height, canopy spread, length of flowering laterals, length of non-flowering laterals and increased number of flushes/m^2 and number of flowering laterals/m^2. Foliar application of 2500 ppm chlormequat chloride has reduced the plant height (36.2%), canopy spread (41.8%), length of flowering laterals (37.4%), length of non-flowering laterals (9.0%) and increased the number of fruits/panicle (10.5%) as compared to control.

3. CROP PROTECTION

During the year, evaluation of extracts from cashew plant parts against cashew stem and root borer (CSRB) adults, field trials on post-treatment prophylaxis, pest population dynamics, and studies on the entomopathogenic fungus; *Metarhizium anisopliae* were conducted to formulate IPM strategy for managing the pest. Similarly studies on tea mosquito bug included, evaluation of new insecticides, effect of smoke on tea mosquito bug (TMB) incidence and host enrichment technique (HET) for enhancing parasitoid activity.

3.1 Cashew Stem and Root Borer (CSRB)

3.1.1 Enumeration of physical characters of infested trees

Observations were recorded on stem girth, age of trees, zone of attack, percentage of bark circumference damaged and stage of infestation (Table 3.1). The percentage of bark circumference damaged and the zone of attack strongly influenced recovery of infested trees after post-treatment prophylaxis with carbaryl (1%) or monocrotophos (0.2%) or lindane (0.2%). All trees with less than 60 cm stem girth succumbed to pest attack, while those having more than 80 cm stem girth recovered (84.6% recovery) indicating that trees with larger girth could tolerate pest damage. Trees aged above 15 years showed 78.9 per cent recovery and infestation when restricted only to collar and stem led to recovery of 89.9 per cent of trees. Another parameter which is of prime importance is the percentage of bark circumference damaged. Complete recovery (100%) occurred in trees with less than 25 per cent of bark circumference damaged and damage beyond 50 per cent of bark circumference led to 97.7 per cent mortality of the infested trees.

Table 3.1 : Physical characteristics of CSRB infested trees.

Physical characteristics	No. of trees in each category	% of trees	
		Recovered	Succumbed
Stem girth (cm)			
< 60	21	-	100.0
60 - 80	177	45.8	54.2
> 80	156	84.6	15.4
Age of trees (years)			
< 10	84	55.9	44.1
10 - 15	232	58.6	41.4
> 15	38	78.9	21.1
Zone of attack			
Collar and root	146	17.8	82.2
Collar and stem	208	89.9	10.1
% Bark circumference damaged			
< 25	86	100.0	-
26 - 50	136	91.2	8.8
> 50	132	2.3	97.7
Stage of attack			
Initial (Without leaf yellowing)	201	100.0	-
Moderate (Without leaf yellowing)	78	15.4	84.6
Severe (with leaf yellowing)	75	-	100.0

3.1.2 Post treatment prophylaxis

Different synthetic pesticides such as lindane, chlorpyriphos and monocrotophos (all at 0.2%) and carbaryl (at 1%) were tested as post treatment prophylaxis after removal of CSRB grubs. Of the 354 trees

showing CSRB infestation, 201 trees were in initial stage of attack (without yellowing of leaf canopy and less than 50 per cent of bark circumference damaged) while 153 trees were in moderate/severe stage of infestation (with either yellowing of leaf canopy or more than 50 per cent of bark circumference damaged). The trees in initial stages of attack could recover fully while those in severe stages of attack succumbed to pest damage inspite of pesticidal treatment. The trees in moderate stage of attack recovered upto 26.3 per cent. Yellowing of canopy was the final indication of infestation followed by death of the tree. Some trees without canopy yellowing also died due to other factors such as root damage or loss of bark circumference beyond 50 per cent. The mean recovery levels, however, were not indicative of efficacy of pesticide tested, as trees were in different stages of attack. Hence stage of pest incidence is of prime concern in recovery of infested trees and pest management is to be taken up prior to extensive damage and yellowing of leaf canopy.

3.1.3 Population dynamics of CSRB

Identifying the period of start of pest incidence is the key factor to undertake suitable plant protection measures. Identification of egg laying or damage by very young (nascent) grubs is not feasible under field condition. In order to develop a method for age determination, the prothoracic shield width (PTS) of CSRB grubs reared in the laboratory was measured at fifteen days intervals. For this purpose PTS width of randomly picked grubs of different age groups was measured. The range and mean values of certain adjacent age groups were found to overlap suggesting the possibility of those groups being in the same instar. Further, the PTS was used to back date grubs collected under field conditions to estimate the probable month of egg laying. The details of morphometrics of grubs are mentioned in Table 3.2.

Table 3.2 : Morphometrics of CSRB grubs *(P. ferrugineus)*.

Age of CSRB grubs (days)	Prothoracic shield width (cm)		Body length (cm)	
	Range	Mean	Range	Mean
Nascent	0.20 - 0.30	0.25	0.4 - 0.8	0.6
15	0.30 - 0.50	0.40	1.0 - 2.5	2.0
30	0.35 - 0.50	0.40	1.0 - 2.5	2.0
45	0.35 - 0.50	0.40	1.0 - 3.0	2.5
60	0.55 - 0.70	0.60	3.0 - 5.0	4.5
75	0.55 - 0.70	0.60	3.0 - 5.0	4.5
90	0.55 - 0.70	0.60	3.0 - 5.0	4.5
105	0.75 - 0.90	0.80	5.0 - 7.0	5.5
120	0.75 - 0.90	0.80	5.0 - 7.0	5.5
135	0.95 - 1.10	1.00	7.5 - 8.5	8.0
150	0.95 - 1.10	1.00	7.5 - 9.0	8.0
165	1.20 - 1.40	1.25	8.5 - 10.0	9.5
180	1.20 - 1.40	1.25	8.5 - 11.0	9.5

The CSRB infested trees were sampled to obtain the different stages of the pest occurring within. The approximate age of grubs was estimated based on the width of prothoracic shield (PTS). The ages of grubs were backdated using the higher range of estimated age for that PTS width. Based on these observations, it was estimated that oviposition might have occurred during all months. However, the peak oviposition occurred between December and May indicating that plant protection needs to be initiated during these critical months, which also are the months for harvesting nuts (Fig.3.1).

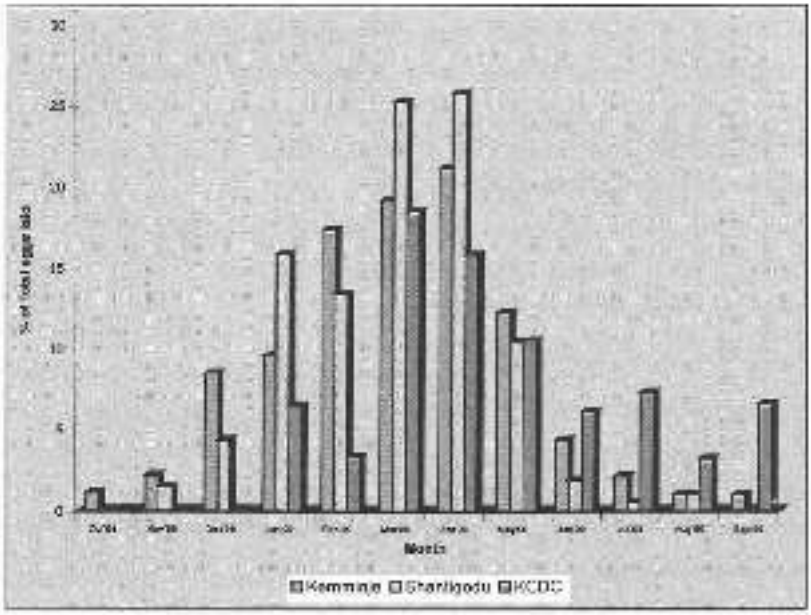


Fig. 3.1 : Estimated percentage egg laying by CSRB during different months

3.1.4 Evaluation of field efficacy of *M. anisopliae*

Spawn of *M. anisopliae* was applied at 250 g/tree along with 500 g neem cake to the base of infested tree after mechanically removing the CSRB grubs. Soil samples were collected at thirty days intervals and the CSRB grubs were allowed to crawl on it for thirty min. and later reared on cashew bark. Mortality was 100 per cent in the samples collected upto ninety days after application.

3.1.5 Studies on plant volatiles (Kairomones)

These investigations were conducted in collaboration with Project Directorate of Biological Control, Bangalore, using the Electroantennogramme (EAG).

The antenna of the live test insect was dissected and immediately fixed into the EAG electrode and various extracts were evaluated by dipping a strip of filter paper (Whatmen no.1) in them and passing an "air puff" through the device provided onto the test antenna. The response was displayed on a computer monitor and all responses were directly logged into the computer. It was observed that the whole length of the antenna was essential to obtain response and the apical tip was the most sensitive region. The antennae were alive and responded for a maximum period of 60 min.

Healthy bark and frass material was extracted with different solvents for a period of 48 h and the extract was later concentrated. The volatiles emanating from healthy bark / fresh frass were trapped in different solvents for 24 h using water suction apparatus. Volatiles thus collected were concentrated and used for EAG studies.

The solvents evaluated were n-hexane, methanol, acetone, chloroform and mixture of chloroform : methanol (2:1 v/v). It was observed that hexane extracts / volatile concentrates elicited the highest response, while chloroform extracts induced fatigue in the test antennae, which could not respond for a further period of 2-4 min. Other solvents led to low to moderate responses. Chloroform was deleted in subsequent evaluations and n-hexane was used as the solvent.

In the first set of evaluations, it was observed that unmated and mated males responded to a lesser degree than females to extracts of fresh frass as well as healthy bark. However, subsequent trials indicated that unmated females responded to a lesser extent than the mated females to extract of fresh frass and healthy bark, which were on par (Table 3.3).

Table3.3 : EAG response of mated female CSRB beetles.

Test Extract	Weight (g)	EAG response
Extract of healthy bark	15	0.381 c
	30	0.418 c
	45	0.311 bc
Extract of fresh frass	15	0.182 a
	30	0.260 ab
	45	0.327 c
Volatiles of healthy bark	15	0.237 ab
	30	0.211 ab
	45	0.277 ab
Volatiles of fresh frass	15	0.269 ab
	30	0.216 ab
	45	0.289 bc
CD at 5%		0.106

Values with the same alphabet are not significantly different

3.2 Tea Mosquito Bug (TMB)

3.2.1 Host plants

During August-September 1999, a survey was undertaken for locating other host plants which harbour TMB during off season. Occurrence of TMB was recorded during the above period for the first time on Singapore cherry trees with severe damage on tender shoots, flower buds and tender fruits resulting in severe flower and fruit drop. Under net house condition, *Helopeltis theivora* was found to breed continuously on Sea Island cotton during above period.

3.2.2 Life table studies of TMB under field condition

Studies conducted under field condition indicated that the survivorship curve of TMB follows Type IV curve (Fig 3.2) having highest mortality during immature stage (egg and nymphs) and prolonged survival of adult stage. The different parameters worked out for life tables are presented in Table 3.4

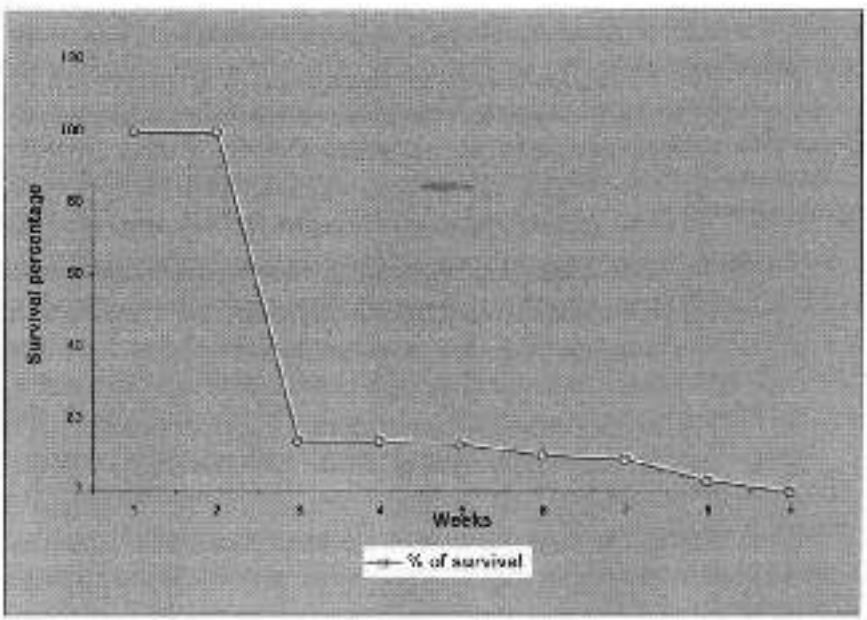


Fig. 3.2 : Survivorship curve of TMB

Table 3.4: Life table studies on *Helopeltis antonii* under field condition

Parameters	Values
Net reproductive rate (R.O) (Total female births)	6.19
Mean length of generation (TC) (days)	35.61
Innate capacity to increase	
calculated r_c	0.0512
corrected r_m	0.059
Infinite rate of increase	1.061
Corrected generation time (days)	30.9
Weekly multiplication of population	1.51
Doubling time (days)	11.74

3.2.3 Chemical control

Five insecticides viz., monocrotophos (0.05%), carbaryl (0.1%), lamda-cyhalothrin (0.005%), acephate (0.075%) and carbosulfan (0.05%) were individually sprayed on young trees. The population of TMB nymphs and adults were caged on the same day, third day and seventh day after spraying. The survival of population and damage score (0-4 scale) were recorded on 24 and 48 hr after caging respectively. Similarly to find out the ovicidal action in eggs and residual action against first instar nymphs, the above insecticides were sprayed on a set of seedlings having TMB eggs along with healthy seedlings with tender flushes. Both TMB egg laden and healthy treated seedlings were tied together in such a way that the newly hatched nymphs can migrate and feed on the tender flushes of healthy treated seedlings. The damage was scored on third day after hatching of nymphs. The results recorded are presented in Tables are 3.5 and 3.6. The results indicated that all insecticides had shown no ovicidal effect, but with maximum residual action against first instar nymphs. However, L. cyhalothrin followed by carbaryl and monocrotophos exhibited highest residual action for 7 days than other insecticides against late instar nymphs and adults and also had least oviposition on

treated shoots. In order to confirm above findings, the above three insecticides were again evaluated, in which L. cyhalothrin was tested at 0.004 per cent instead of 0.005 per cent and the results (Table 3.7) also confirmed these findings.

Table 3.5: Residual effect of new insecticides on survival and damage of TMB.

Treatments	No. surviving after 24 h				Damage grade at 48 h			
	0 day	3rd day	7th day after spraying	Mean	0 day	3rd day	7th day after spraying	Mean
Monocrotophos 0.05%	0.0aA	0.0aA	0.0aA	0.0a	0.3	1.3	2.0	1.2b
Carbaryl 0.1%	0.0aA	0.0aA	0.0aA	0.0a	0.7	0.7	3.0	1.4bc
Lcyhalothrin 0.005%	0.0aA	0.0aA	0.0aA	0.0a	0.0	0.3	1.3	0.6c
Acephate 0.075%	0.0aA	0.0aA	3.7cB	1.2c	0.3	2.3	3.3	2.0cd
Carbosulfan 0.05%	0.0aA	0.0aA	1.3bB	0.4b	1.7	1.7	2.7	2.0c
Control	6.0bA	6.0bA	6.0dA	6.0d	3.3	3.7	4.0	3.7e
Mean	1.0A	1.0A	1.8B		1.1A	1.7B	2.7c	

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

Table 3.6: Residual effect of new insecticides on oviposition, hatching of eggs and damage of first instar nymphs of TMB.

Treatments	No.of eggs/female laid during 48 h				Hatching of eggs (%)	Damage grade by 1st instar nymphs
	0 day	3rd day	7th day after spraying	Mean		
Monocrotophos 0.05%	*4.3cB	*1.0aA	*2.8abAB	2.7ab	98.4	0.0a
Carbaryl 0.1%	*3.0bA	*1.8aA	*3.8abA	2.9bc	100.0	0.0a
Lcyhalothrin 0.005%	0.0aA	1.8aA	*1.5aA	1.1a	100.0	0.0a
Acephate 0.075%	*7.3cB	*0.8aA	*10.7cB	6.3c	97.8	0.0a
Carbosulfan 0.05%	*3.0bA	*1.5aA	*11.8cdB	5.4bc	96.5	0.0a
Control	*22.7dA	*25.0bA	*19.3dA	22.3d	100.0	4.0b
Mean	6.7AB	5.9A	8.3B		NS	

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

* Egg parasitism was observed in some of the replications.
NS Non significant

Table 3.7: Comparison of residual effect of L-cyhalothrin with monocrotophos and carbaryl on survival and damage of TMB.

Treatments	No. of surviving after 24 h on			Damage grade after 48 h		
	3rd day	7th day after spraying	Mean	3rd day	7th day after spraying	Mean
Monocrotophos 0.05%	0.0	0.0	0.0a	0.3aA	1.8bB	1.0a
Carbaryl 0.1%	0.0	0.0	0.0a	0.3aA	1.8bB	1.0a
L.cyhalothrin 0.004%	0.0	0.5	0.3a	0.0aA	1.3aB	0.6a
Control	4.0	4.0	4.0b	3.0bA	3.0cA	3.0b

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

In the cashew plot, 10 trees were individually smoked for thirty minutes at early morning twice a week in both Shantigodu and Kemminje cashew farms. Before smoking, the tender shoots of respective trees were caged with known number of population (nymphs and adults) of TMB. The survival of population and damage were recorded on 24 and 48 h after caging respectively. The results indicated that all the released population (2-6 no./cage) had survived and caused highest damage (grade-3) equal to untreated control.

3.2.4 Biological control

For this purpose, the gravid females were caged in adult parasitoids exclusion (muslin cloth) cage for 36 h. After removing the cage, the egg laden shoots were treated separately with monocrotophos (0.05%), carbaryl (0.1%) and L. cyhalothrin (0.005%). For untreated control, two set of cages were used. In the first case, mosquito net (mesh) was used for 36 h wherein the entry of adult egg parasitoids is possible and in the second case, adult parasitoid

exclusion cage was used for the same period. In both treated and untreated shoots, the extent of egg parasitism was recorded on thirtieth day after exposure. The results indicated that in the untreated control where mesh cage was used, highest parasitism of 83.2 per cent was recorded. Whereas, with muslin cloth cage, the extent of egg parasitism was 16.5 per cent which was almost equal to other insecticidal treatments and it ranged from 12.2 to 34.1 per cent. Thus, it provides an indication that the activities of egg parasitism are not affected due to insecticidal spraying (Table 3.8).

Table 3.8: Bioassay of Recommended insecticides for the safety to egg parasitoids of TMB.

Treatments	% of egg parasitism
Untreated control	
Mesh cage	83.2 (321)
Muslin cloth cage	6.7 (108)
Monocrotophos (0.05%)	34.1 (88)
Carbaryl (0.1%)	17.1 (211)
Lambdacyhalothrin (0.005%)	12.2 (180)

Figures in parantheses indicate total no. of eggs.

The nymphal and adult population of TMB were periodically sampled for the presence of nymphal adult parasitoid (NAP). The occurrence of NAP was observed only in the month of June and at a very low rate (1.1%) out of 490 nymphs and adults of TMB examined from April to December 1999.

The egg endoparasitoids (*Telenomus* sp. and *Chaetostricha* sp.) of TMB was encountered in TMB eggs collected from sprayed (monocrotophos / carbaryl) plots with highest parasitism of 53.2 per cent (Fig. 3.3). But the relative emergence of egg parasitoids was quite low especially during regular infestation period (from October onwards). Thus, it gives a scope that during severe infestation period of TMB (October-December), the insecticidal application can be practiced with least environmental consequences on egg parasitism of TMB.

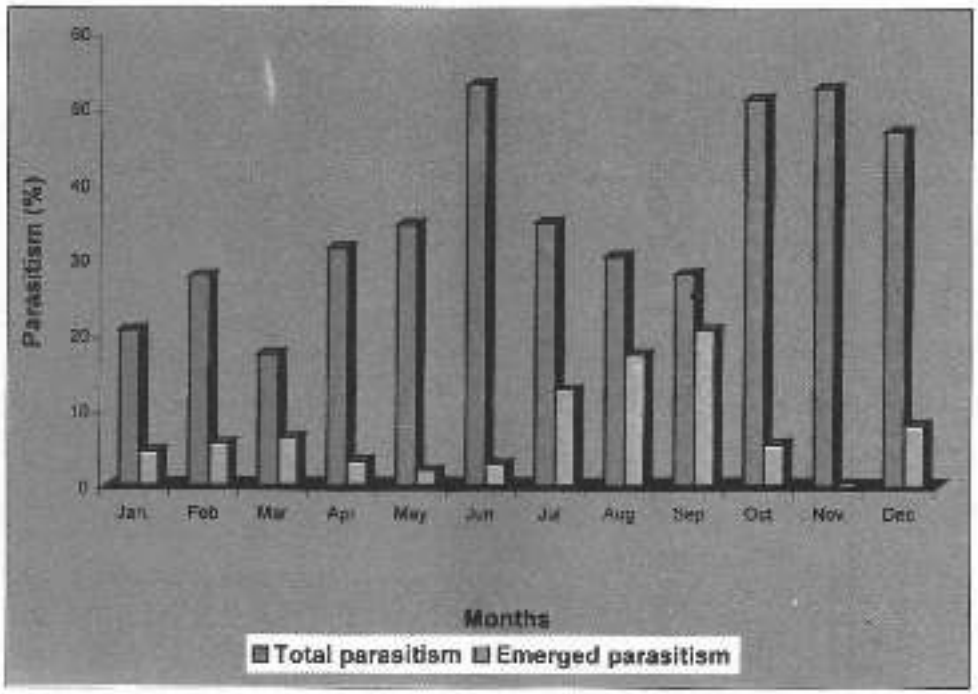


Fig. 3.3 : Egg parasitism of TMB by egg parasitoids under field condition during 1999.

Two species of legumes (*Crotolaria* sp. and wild red gram) grown in the unsprayed plot of Goa 11/6 were found to be attractive to hymenopteran and dipteran adults. The *Crotolaria* sp. contains extra floral nectaries (68-98 no./flowering and fruiting panicle) which are attractive to stingless honey bees (melliponids), adult parasitoids of hymenopteran and dipteran groups, adult coccinellid predators, spiders and ants.

4. POST HARVEST TECHNOLOGY

4.1 Value addition in cashew

Processing of cashew results in kernels of different grades like wholes, splits and bits. Although, kernels of all the grades are commercially marketed, cashew kernel baby bits fetch less. As such attempts have been made to develop products from low grade cashew kernel baby bits.

4.1.1 Preparation of milk

Cashew kernel baby bits was finely homogenized with distilled water to form a fine paste and stored at 6 to 10^{0}C and < 0^{0}C. Milk was constituted by blending 10 g paste with 100 ml distilled water and decanted after 24 h at 6 to 10^{0}C. Decanted milk was diluted to 200 ml. Protein and sugar in the milk was analysed (Table 4.1). Protein content in the milk did not change upto 34 days of storage. Sugar content, however, decreased considerably after 25 days of storage. Cashew kernel paste after storage at 6 to 10°C for 7 days had fermented smell. Hence, organoleptic analysis of milk prepared from kernel paste stored at < 0°C only was done.

Sweetened milk (20 g/200 ml) and flavoured with cocoa (50 mg/200 ml) prepared from cashew kernel paste during storage at < 0^{0}C was organoleptically assessed for colour, flavour and taste by a panel of judges of fifteen to twenty (Table 4.2). Mean cumulative score of the sweetened and flavoured milk did not change during storage indicating that cashew kernel paste could be stored at < 0°C upto 34 days without affecting the organoleptic acceptability. Inclusion of sodium benzoate (12.5 mg/50 g), soya lecithin (1 g/50g), cane sugar (5 g/50 g) in the cashew kernel paste did not have any additional advantage.

Table 4.1: Protein and sugar content of milk prepared from kernel paste during storage at < O°C .

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

Values are mean of three individual estimations

A - Paste prepared from cashew baby bits alone.

B - Paste prepared from cashew baby bits with sodium benzoate as a preservative.

C - Paste prepared from cashew baby bits with cane sugar and sodium benzoate.

D - Paste prepared from cashew baby bits with cane sugar.

Table 4.2: Mean cumulative mean scores for colour, flavour and taste of sweetened and cocoa flavoured milk prepared from kernel paste during storage at < O°C .

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

A, B, C, D - Same as in Table 4.1

4.1.2 Preparation of cashew kernel spread

Cashew kernel baby bits (50 g) was finely homogenized with cane sugar (5 g), iodised salt (0.1 and 0.5 g), vanillin (0.1 g) and refined groundnut oil (10 ml) to form a fine smooth paste. The spread thus prepared was stored at < 0°C for 24 h before organoleptically analysed by a panel of judges of fifteen to twenty for colour, flavour, spreadability, consistency and taste (Table 4.3). Vanillin flavoured sweetened spread is the most preferred (13.9) while salted spread is least preferred (18.7). Inclusion of soy lecithin, an emulsifier and sodium benzoate, a preservative, did not improve the organoleptic acceptability of cashew spread.

Table 4.3: Organoleptic analysis of cashew spread for colour, flavour, spreading character, consistency and taste.

Spread	Mean cumulative Hedonic scale
Sweetened spread (5g/50g)	15.1
Salted spread (0.5g/50g)	18.7
Salted spread (0.1g/50g)	17.0
Sweetened spread containing soy lecithin (1g/50g)	16.6
Salted spread (0.5g/50g) containing soy lecithin (1g/50g)	18.0
Sweetened spread (5g/50g) containing soy lecithin and sodium benzoate (12.5 mg/50g)	16.1
Salted spread (0.5g/50g) containing soy lecithin (1g/50g) and sodium benzoate (12.5 mg/50g)	17.3
Cocoa flavored (0.1g/50g) sweetened (5g/50g) spread	15.5
Sweetened (5g/50g) and salted (0.1g/50g) spread	15.5
Vanillin flavoured (0.1g/50g) sweetened spread (5g/50g)	13.9

4.1.3 Keeping quality of cashew kernel oil

In order to develop cashew kernel oil based products, oil has been extracted and keeping quality at ambient temperature (27 to 30°C) has been studied. Oil from cashew kernel baby bits has been extracted with n-hexane and refined with alkali after removal of organic solvent. Quality of the oil was assessed in terms of iodine value, peroxide value, acid value and saponification value during storage (Table 4.4). Both iodine value and saponification value did not change upto 4 months beyond which both the values increased shaply. Both acid value and peroxide value increased during storage. These results indicate the requirement of addition of antioxidants for improving the keeping quality of cashew kernel oil.

Table 4.4: Keeping quality of refined oil of cashew kernel baby bits at ambient temperature.

Parameters	Storage period (months)			
	0	2	4	6
Iodine value	18.3	18.9	18.4	61.2
Acid value	0.39	0.25	0.57	0.70
Peroxide value	9.0	18.2	29.6	67.1
Saponification value	325.9	315.9	331.1	356.1

4.1.4 Coating of baby bits with cane sugar and honey

Studies on coating of baby bits (BB) with cane sugar and honey have been initiated under an adhoc scheme on value addition in cashew. Coating of cashew kernel baby bits with cane sugar at different temperatures (60, 80 and 100°C) at concentrations ranging between 50 and 100 per cent was done. Ratio of baby bits to the sugar syrup was 1:2 and coating was done for 5 min. Coated baby bits were extracted at 10°C for 12 h with distilled water and the filtrate was used for sugar estimation. Results presented in Fig.4.1 indicate that maximum coating of sugar occurs at 70 per cent concentration at 100°C. Similarly coating of baby bits with honey was attempted at 60, 80 and 100°C

at concentrations ranging between 30 and 70 per cent. Beyond 70 per cent coating could not be attempted as the honey solution becomes very thick. Maximum coating of baby bits with honey occurs at 70 per cent concentration at 100^{0}C (Fig.4.2).

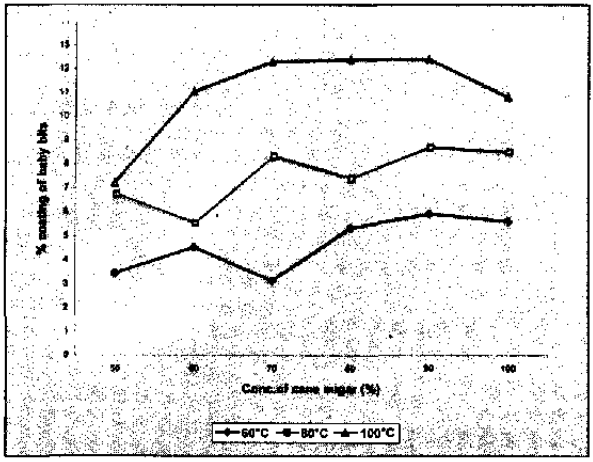


Fig. 4.1 : Coating of baby bits with cane sugar at different temperatures

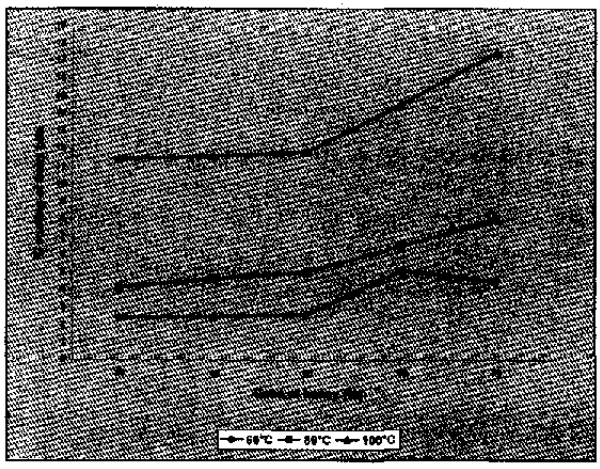


Fig. 4.2 : Coating of baby bits with honey at different temperatures

Cashew kernel baby bits (BB) were defatted with n-hexane at ambient temperature over a period of 48 h and baby bits were dried at 70°C for 6 to 8 h and used for coating studies. Coating of defatted cashew kernel baby bits (BB) and whole baby bits with 70 per cent cane sugar and honey at 60 to 100°C was compared (Table 4.5). Higher per cent coating of cane sugar and honey has been noticed with defatted kernel baby bits compared to whole kernel bits. This would be advantageous to prepare low calorie sugar / honey coated baby bits for calorie conscious consumers.

Coating of baby bits (BB) with different sugars was attempted in order to see whether sugars exhibit differential coating (Table 4.6). Sugars exhibit differences with respect to per cent coating. Least coating of baby bits has been noticed with fructose (5.89%) while highest coating has been observed with lactose (11.5%).

Table 4.6 : Coating of cashew kernel baby bits with different sugars.

Sugars (%)	% Coating
Cane sugar	10.48
Honey	12.32
Sucrose	8.76
Glucose	11.00
Fructose	5.89
Lactose	11.50

Values are mean of three individual estimations

Table 4.5 : Coating of defatted cashew kernel baby bits with cane sugar and honey.

	Conc. (%)	Temp (°C)	% Coating	
			Whole baby bits	Defatted baby bits
Honey	70	100	13.90	12.70
		80	8.67	15.33
		60	6.36	13.89
Cane sugar	70	100	9.70	16.10
		80	4.45	9.36
		60	5.71	12.20

Values are mean of three individual estimations

5. TRANSFER OF TECHNOLOGY

5.1 Establishment of model cashew clonal garden

Out of thirteen plots visited for laying out model cashew clonal garden (demonstration plots) under central sector scheme of DCCD, Cochin, in Puttur, Belthangady and Sullia taluks, ten plots were selected. Grafts of Goa 11/6, Hybrid 32/4 and Sel-2, have been planted in these demonstration plots. With these the number of plots raised under this programme comes to seventy eight. Orientation training was conducted during July 1999 to explain about planting and after care for newly selected demonstration farmers.

All the demonstration plots laid out so far were monitored and farmers were advised regarding organic manure/fertilizer application, pruning, soil and water conservation techniques and plant protection measures.

The yield potential of VTH 174 was assessed in farmers' plots. The average yield ranged between 1.0 and 6.5 kg/tree in eleven year old orchards and 2.0 and 7.5 kg/tree in twelve year old orchards.

5.2 Soil and water conservation and plant protection campaigns

Series of campaigns were conducted in Dakshina Kannada and Kasaragod districts to create awareness on the need for soil and water conservation and plant protection measures. These campaigns were conducted in collaboration with Department of Agriculture, Kerala and DCCD, Cochin. The main objective was to educate farmers on the need for soil and water conservation measures and to explain the key factors involved in the management of tea mosquito bug (TMB) and cashew stem and root borer (CSRB).

5.2.1 Selection of farmers

Emphasis was given to involve only selected farmers for the programme as the adoption of soil and water conservation and plant protection measures in cashew involves committed interest in protecting soil and management of the pests. For this purpose, a press note was issued regarding the programme in local newspaper and announcements were broadcast from All India Radio stations. Pamphlets were also distributed to the farmers around the

campaign village. To ensure the participation of interested farmers in the campaign they were requested to inform the organizers well in advance.

5.2.2 Execution of the campaigns

Four campaigns were organized in Dakshina Kannada (Karnataka) and Kasaragod districts (Kerala). On the day of the campaign the farmers gathered at the specified venue. The technique of soil and water conservation and plant protection were explained to them with the help of charts and specimens specially designed. Method of terracing, water conservation in plain land and opening catch pit, method of coconut husk burial etc. were explained to them. The farmers were educated about initial symptoms of tea mosquito bug damage and different insecticides used for its management. The need for mixing fungicides and insecticides in die-back prone area was also explained to them. To overcome the problem of cashew stem and root borer (CSRB) need for phytosanitation in cashew plantation was also emphasized.

Soil and water conservation campaigns

Soil and water conservation campaigns

5.2.3 Highlights

- Attention was focussed mainly on selected topics of immediate attention.
- Krishi Vigyan Kendra (CPCRI, Kasaragod) and Department of Agriculture (Kerala Govt.) also collaborated in organizing the campaigns.
- Arrangements were made in village settings to facilitate better discussion with farmers.

- Host farmers participated actively and the arrangements were made by them.
- Response from the farmers was encouraging and a total of 598 farmers participated in these campaigns.

5.3 Training programme on utilization of cashew apple for farm women

A training programme was organized in collaboration with Krishi Vigyan Kendra, CPCRI, Kasaragod and CFTRI, Regional Centre, Mangalore during March 2000. The programme was financed by DCCD, Cochin. In the programme eighty trainees sponsored by Department of Agriculture, Kerala participated. Preparation of squash, jam and chutney was demonstrated to the trainees. The farm women felt that the steps involved in the preparations were simple and easy to follow. Products prepared were acceptable to them. Orange, pineapple, lime, apple, mango and ginger can also be mixed with apple juice to produce variety of squash. These preparations can be preserved for 6 to 8 months at refrigerated temperature (10^0C) and one can relish the taste of cashew apple even during off season.

Training programme on utilization of cashew apple

5.4 Annual Cashew Day

Annual Cashew Day was organized on 4th March 2000 to make the cashew farmers aware of latest developments in cashew production technology and to get their feedback. Press note was issued in local newspapers and arrangements were made for announcements in All India Radio stations to select the interested farmers. Letters were also sent to demonstration farmers and the farmers who attended the soil and water conservation and plant protection campaigns and Non-Governmental Organisations. The interested farmers confirmed their participation well in advance.

A total of 150 farmers from Dakshina Kannada, Udupi, Madikeri, Tumkur and Kasaragod districts participated in the cashew day. They were taken to experimental plots both in Kemminje and Shantigodu campuses of NRCC to explain about germplasm collection, high density planting, soil and water conservation measures, maximization of yield in cashew, pruning, composting of cashew leaves and top working. A special seminar was organized in which progressive farmers shared their experience regarding varieties of cashew, initial establishment of cashew orchards, organic farming and plant products usage in pest management. This was followed by discussion in which farmers' doubts on various aspects of cashew cultivation were cleared.

During the cashew day four booklets in Kannada were distributed to all the farmers namely i) Farmers' experience in cashew growing ii) Information about field visits iii) Cashew apple preparations and iv) Farmers' doubts in cashew cultivation and their solutions.

There was no registration fee and the entire arrangement for field visit and hospitality of the farmers were made by the host institute. The farmers participated actively in field visits and seminar. Non Governmental Organisations like Sri Kshetra Dharmasthala Rural Development Project, Dharmasthala; Bharatiya Agro Industries Foundation, Tiptur and Kisan Sangha, Udupi/Puttur sponsored farmers for participation in cashew day. Many farmers expressed their desire to participate in similar programme of the centre in future and in following improved cashew production technologies.

Annual Cashew Day

Demonstration of Japanese method of composting during Annual Cashew Day

6. CONCLUDED PROJECT

6.1 Tissue culture studies in cashew for micropropagation and somaclonal variation.

Project Leader : Dr. Thimmappaiah (1990-2000)
Associate : Mrs.Shirly Raichal Anil (1994-2000)

Project No.1.3

6.2 Introduction

Cashew is both seed and vegetatively propagated. The latter method is now practised commercially through softwood grafting. Since the demand for grafts is so high, there is an urgent need to develop a faster method of multiplication preferably through micropropagation. This will not only supplement the conventional method and can be used in such research applications as regeneration of transgenic plants and in vitro conservation of germplasm. As cashew was introduced to India only 400 years back, the gene pool available for breeders is low. There is a need for exploiting somaclonal variation observed in tissue culture to increase the variability. Hence, regeneration of plants from callus and screening them for somaclonal variability will be useful.

6.3 Objectives

- To standardise micropropagation technique in cashew.
- To induce and exploit somaclonal variation for breeding purpose.

The orientation was on the first objective viz., micropropagation as it was the main objective.

6.4 Materials and methods

6.4.1 Regeneration studies with seedling explants

a) Explants

For explanting purpose, mature seeds of cashew were sterilised in 20 per cent bleach (20 min) and sown in trays containing sterile sand. Seedlings germinated 25-30 days after sowing were used for collecting shoots. Similarly from

mature trees green nuts were collected and after sterilisation embryo with part of the cotyledon were extricated and inoculated onto various solid media (MS, WPM and B5) containing activated charcoal, and NAA (0 and 0.2 mg/l).

b) Disinfection procedures

Disinfection procedures for various explants (nodes, shoot tips, cotyledonary nodes) were worked out viz., first immersion in 70 per cent ethanol (30-45 sec.) followed by agitation in sterilants like mercuric chloride (0.1 -0.2%), bleach (20%), bleach+ mercuric chloride. The shoot explants were agitated in carbendazim (0.2%) for various duration to reduce fungal contamination. Similarly, for reduction of bacterial infection various antibiotics (gentamycin, neomycin, neomycim+gentamycin) were incorporated in the media after filter sterilization and contamination were scored.

c) Control of browning and exudation

Activated charcoal (0.1-0.5%), ascorbic acid (0.01-0.02%) ascorbic acid (0.01%) + citric acid (0.015%), PVP-40 (1 g/l), activated charcoal (1 g/l) + ascorbic acid (0.1%), cysteine (0.1%) were incorporated into the media. Number of viable shoots or green shoots were recorded in addition to budding of explants.

d) Initiation /Establishment media for nodal cultures.

For establishing nodal cultures, four basal madia viz., Murashige and Skoog's (1962), Woody Plant Medium (Llyod & McCown, 1980) B5 medium (Gamborg et al 1968), and RBM (Raj Bhansali 1990) supplemented with 3 per cent sucrose and with/without BAP were tried. Different salt concentration were tried in MS medium like $^{1}/_{4}$MS, $^{1}/_{2}$MS, $^{3}/_{4}$MS and full MS were used with BAP (5 mg/l). Budding percentage and viability of shoots were recorded after 5-6 weeks.

e) Multiple shoot induction

On nodal cultures, the effect of BAP, Kin, 2iP (0.5, 1.0, 2.0, 4.0, and 8 mg/l) and adenine sulphate (Ads) (10, 20, 40, 80, and 160 mg/l) were tested singly in basal MS medium. BAP, Kin, 2iP and zeatin (Zn) were used in combination of two at 0.5 and 1.0mg/l each in MS media. Thidiazuron (TDZ) was incorporated into the MS media alone (0.1-2 mg/l) or in

combination with BAP and IBA. The number of multiple shoot buds induced per nodal culture was recorded.

f) Multiple shoot induction in cotyledonary nodes

Cotyledonary nodes from 3-4 week old seedlings without their cotyledonary segments were cultured after the sterilisation procedure, on 3/4 MS medium supplemented with filter sterilised zeatin (0.5-4.0mg/l). Decapitation of in vitro germinated seedlings on in vitro germination medium was also done to induce multiple shoots. Cotyledonary nodes were cultured on MS medium containing BAP (2.25mg/l) and IBA (0.2mg/l). The number of multiple shoots induced were recorded and the multiple shoot obtained were separated and sub-cultured on the same medium for repeated induction of multiple shoots and elongation.

g) Shoot bud elongation

Shoot bud elongation in multiple shoots was tried on liquid medium containing BAP, Kin and zeatin at 2 and 5mg/l by agitation. Alternatively, two semi-solid media were tried viz.,l) Modified MS medium containing sucrose 5percent, maltose (5 g/l), BAP (1 mg/l) and coconut water(10%) and ii) Modified MS medium (Raj Bhansali 1988) for shoot bud elongation. Half MS medium with glutamine (400 mg/l) without hormones was also tried for elongation.

h) Rooting of microshoots

In vitro rooting

Microshoots which are 2cm or more were tested for rooting ability on semi-solid half-strength MS medium containing 3 per cent sucrose, 1g/l PVP-360 and supplemented with NAA, IBA and IAA at 2.5 and 5.0mg/l each and in combination of two at 2.5 mg/l each. The number of explants which showed response to rooting, number of roots obtained and duration for rooting were recorded.

Ex vitro rooting

The microshoots were rooted ex vitro by dipping them in 250ppm each of IAA, NAA and IBA for 48 h in dark and potting them in mixture containing 1:1:1 sand, soilrite and coconut pith and covered with beaker and irrigated with 1/5 MS salt solution. Rooting percentage was recorded after 6-8 weeks of potting. Similarly pulsing shoots in 10mM solution of NAA and IBA for 2 min was attempted. The treated shoots was cultured on hormone free basal medium for expression of roots.

i) Hardening and acclimatisation

The in vitro rooted plantlets were hardened first on half-strength MS liquid medium containing 1.5 per cent sucrose and then on the same medium without sucrose for 2-3 weeks in each medium. The hardened plantlets were potted in potting mixture containing 2:1 sand and soilrite. The potted plants were irrigated with sterile distilled water and 1/10 MS salt solution and provided humidity by covering the plants with polythene bags and gradually the number of holes were increased before it was fully removed. The acclimatised plants were hardened further in green house on ordinary potting mixture.

6.4.2 Regeneration from mature tree explants

Nodal and shoot tips excised from young cashew grafts (1-2 year old) maintained in green house as well as from field grown trees (10-14 year old) were used for culturing. Sterilisation of explants from green house was done in 0.1 per cent mercuric chloride (5 min) and for field explants 20 per cent NaClO (15 min) followed by immersion in 0.05 per cent $HgCl_2$ (10 min) was tried.

For initiating nodal cultures, semi-solid media containing half and full strength Murashige and Skoog's (1962) (MS) salts, Woody Plant Medium (Llyod and McCown (1981), B_5 medium (Gamborg et.al., 1968) and SH medium (Schenk and Hildbrandt,1972) were tried. Bud break in explants was recorded. Effect of addition of L-glutamine, activated charcoal and other anti-browning substances (PVP-360, PVPP, ascorbic acid) were also tried. Contamination free cultures were subjected to multiple shoot induction on MS basal medium consisting half strength major nutrients and supplemented with various levels of thidiazuron (TDZ) (0.1, 0.5, 1.0mg/l), 6-benzylamino purine (BAP) (0.5, 1.0, 2.0 mg/l) alone and 0.1 mg/l of TDZ in combination with BAP (0.5, 1.0, 2.0 mg/l) along with a common level of 0.5mg/l GA_3 and 0.1mg/l IBA. Number of multiple /axillary shoot buds per explant were recorded after 6 weeks.

6.4.3 Callus induction

Callus was initiated from leaf, internode and cotyledon (mature and immature) on MS medium containing various levels of 2,4-D with low concentration of BAP/Kin in dark. Callus multiplied were put on regeneration medium for plantlet regeneration.

6.4.4 Embryogenesis

Nucellus was excised from bisected ovule (3-4 week old) of M44/3 and T.No.1. The induction media was modified MS containing half the level of major nutrients, 6 per cent sucrose, glutamine (400 mg/l) and gelled with 0.8g/l agar. The calli

induced was multiplied on NAA and zeatin medium. The embryogenic structures obtained were matured on ABA and germinated on hormone free medium.

6.5 Results and Discussion

Although the project was started with a twin objective, the programme was largely concentrated on standardisation of micropropagation technique through shoot tip and nodal culture.

6.5.1 Control of contamination

Contamination of cultures was depended on season of collection, source and type of explant. The contamination was maximum (100%) during rainy season (June to September) and least during January to April. Among the explants, shoot tip had higher contamination than the nodal cuttings. Explants from field grown trees were found to be highly contaminated than nursery raised grafts. Among the various sterilants used for sterilisation of explants, only mercuric chloride and chlorine tablets (2.5% available chlorine) was effective. For nodal explants excised from one month old seedlings (nursery raised) dip in 0.1 per cent $HgCl_2$ for 5 min and for shoot tips 5 min. dip in 0.2 per cent $HgCl_2$ was effective. However, 100per cent contaminant free cultures could be established by raising seedlings in vitro. Shoot explants from mature trees of field origin showed high contamination in cultures and required double sterilisation i.e., first in bleach (20%) for 20 min. then in 0.05 per cent $HgCl_2$ for 10 min. Maintainance of young cashew grafts hygienically (established from field trees) in green house and sterilising the explants in 0.1per cent $HgCl_2$ for 5 min. under constant agitation resulted in 80 per cent contaminant free cultures (Table 6.1).

Table 6.1 : Sterilization treatments for different explants.

Explant	Source	Effective sterilant/conc.
Shoot tip	Seedling (1month)	0.1% $HgCl_2$ (5min.)
Nodal cuttings	Seedling (1month)	0.2% $HgCl_2$ (5min.)
Cotyledonary node	Seedling (1month)	0.2% $HgCl_2$ (15-20min)
Shoot tips and nodal cuttings	Young cashew grafts (green house maintained)	0.1% $HgCl_2$ (5-8min.)
Shoot tips and nodal cuttings	Field origin	Bleach (20%) (20min)+ 0.05% $HgCl_2$ (10min.)

For controlling bacterial contamination culturing shoot explants in solid medium incorporated with either neomycin (1000ppm) or a combination of gentamycin and neomycin (500ppm each) was effective (Table 6.2). In another instance spraying shoots with chlorotetracyline (50ppm) and incorporating in media was also helpful for reduction of bacterial contamination. Fungal contamination was most predominant and it was identified as *Fusarium* species. Fungal contamination was reduced to nil when the explants were constantly agitated in Bavistin (0.5%) (Carbendazim) for 4 h prior to sterilisation.

Incorporation of micostatin (40mg/l) a fungistatic substance was tried in liquid media. It was observed that micostatin had no significant effect on control of fungal contamination.

Table 6.2 : Effect of gentamycin and neomycin on contamination of shoot cultures.

Medium	% contamination
MS + Antibiotics (0)	39.1
MS + Gentamycin (500mg/l)	16.7
MS + Gentamycin (1000mg/l)	8.3
MS + Neomycin (500mg/l)	12.6
MS + Neomycin (1000mg/l)	0.0
MS + Gentamycin (500mg/l) + Neomycin (500mg/l)	0.0

6.5.2 Control of browning and exudation

The nodal explants from seedlings had less problem of browning, but exudation from cut ends after inoculating into the media was more. To overcome this, activated charcoal (AC 0.1%), ascorbic acid (0.01-0.02%), ascorbic acid (0.01%) + citric acid (0.015%), PVP-40 (1 g/l), AC (1g/l) + ascorbic acid (0.01%) and cysteine HCl (0.1%) were incorporated in MS medium. Exudation was least (19%) in the media incorporated with cysteine hydrochloride (0.1%).

Nodal explants of mature trees were susceptible to cutting injury and explants showed exudation and browning after inoculation onto solid media. To overcome this, AC (0.1 - 0.4%), PVP-360 (0.1%), polyvinyl polypyrrolidone (PVPP 0.1%), ascorbic acid (100 mg/l), were incorporated in MS medium. Although exudation was observed from cut ends in media with PVP-360, culture response was best in terms of bud break and number of leaves formed. However, there was no significant difference in the response.

6.5.3 Media for nodal cultures

For establishing nodal cultures of seedling origin, three basal media namely Murashige and Skoog (1962), Woody Plant Medium (Lloyd and McCown, 1980) and B5 medium (Gamborg et al., 1968) supplemented with 3% sucrose, AC (0.1%), 5 mg/l of BAP and gelling with agar (8 g/l) were tried. Only on MS medium, the nodes established better with maximum shoot length of 1.4 cm (Table 6.3).

MS media containing BAP (5 mg/l) at one-fourth, half, three-fourth and full salt levels was also tested. At three-fourth level of salt in MS medium best response was observed with maximum production of single shoots (75%) (Table 6.4).

Similarly for nodal explants of mature tree origin different basal media (SH, MS, WPM), were tested by supplementing media with 2 g/l of AC and gelled with 2.25 g/l of phytagel. MS basal medium modified to contain half the level of major nutrients with 400 mg/l L-glutamine and 0.2 per cent AC supported better establishment of nodal cultures.

Table 6.3 : Effect of different mineral media on nodal culture establishment of seedlings.

Medium	No. of explants used	Bud break		Length of shoot (cm)
		Freq.	%	
MS + BAP (5 mg/l)	24	23	95.8	1.4
WPM + BAP (5 mg/l)	24	24	100.0	0.9
B_5 + BAP (5 mg/l)	24	20	83.3	0.9

Table 6.4 : Effect of salt concentration (MS) on nodal cultures (seedlings).

Medium	No. of explants used	Bud break		Length of shoot (cm)	
		Freq.	%	Freq.	%
$^1/_4$ MS + BAP (5 mg/l)	22	20	90.9	8	36.4
$^1/_2$ MS + BAP (5 mg/l)	24	20	83.3	13	54.2
$^3/_4$ MS + BAP (5 mg/l)	24	19	79.2	18	75.0
Full Ms + BAP (5 mg/l)	23	15	65.2	9	39.1

6.5.4 *In vitro* seed germination

In order to get aseptic seedlings for explanting purpose half-mature seeds were sterilized first in 70 per cent alcohol and then in chlorine tablet (2.5% available chlorine) along with a drop of Tween-20 for 30 min by constant agitation. Growing point (embryo) with part or full cotyledon was extricated and inoculated on to 3 sets of semi-solid media namely, MS, WPM and B5 containing 2 g/l AC and 0 or 2.0 mg/l NAA. Germination was done under 16/8 h photo period. Highest germination of 89 per cent was observed in WPM supplemented with NAA (2 mg/l) (Table 6.5).

Table 6.5: *In vitro* seed germination on semi-solid medium.

Media	Germination (%)	Height (cm)
Half MS + NAA (0)	42.1	4.4
Half MS + NAA (2 mg/l)	36.8	2.0
WPM + NAA (0)	58.8	4.8
WPM + NAA (2 mg/l)	89.4	5.4
B_5 + NAA (0)	52.3	5.7
WPM + NAA (2 mg/l)	76.4	7.5

Apart from this, mature seeds were also germinated in screw cap bottles containing absorbent cotton presocked with sterile distilled water.The seeds were first softened with conc. HCl for 20 min and then sterilized with 20 per cent NaClO for 30 min under constant agitation. After 20-25 days of inoculation over 90 per cent germination was recorded in dark.

6.5.5 Axillary shoot-bud proliferation in explants of seedling origin

Axillary shoot-bud proliferation in shoot explants was dependent on source of explant, type of explant and the kind of cytokinin employed in the medium for the above purpose. For multiple shoot-bud induction cotyledonary nodes, nodal cuttings and shootlips were used. Among the three explants used, coteledonary nodes were more potent. Explants from in vitro seedlings exhibited shoot-bud proliferation. Among the different cytokinins tried (BAP, kinetin, 2iP, zeatin, thidiazuron), thidiazuron was most potent for multiple shoot-bud induction irrespective of type of explants.

a) Cytokinin effect on multiple shoot induction

Effect of BAP, kinetin, 2iP and adenine sulphate (Ads) was tested singly in MS media for multiple shoot induction in nodal cultures. In MS media, BAP, kinetin and 2iP were tried at 0.5, 1.0, 2.0, 4.0 and 8.0 mg/l while Ads was tried at 10, 20, 40, 80 and 160 mg/l. BAP, kinetin, 2iP and zeatin (Zn) were also used in combination of two at 0.5 and 1.0 mg/l each in MS media. Although there was some multiple shoot induction in some treatments, there was no significant difference between the treatments. For single shoot production 160 mg/l of Ads, 1 mg/l of 2iP and 0.5 mg/l of BAP was best with more than 70 per cent of the explants forming single shoots. BAP and zeatin in combination at 1 mg/l also yielded single shoots in 77 per cent of the explants. Combinations involving zeatin showed multip e shoot - induction in small percentage of explants (5.9 to 23.1%).

b) Induction of multiple shoots using thidiazuron (TDZ) in media.

Nodal cuttings and shoot tips excised from *in vitro* raised seedlings of H 4.7 were cultured on three-fourth MS medium supplemented with 0.1 - 2.0 mg/l of TDZ. Within 2-4 weeks, the explants showed

shoot bud proliferation (1-5 buds/explant) in 55.5 to 85.7 per cent of the explants, the best response being in 0.1 mg/l of TDZ. (Table 6.6). The shoot-bud proliferation continued even on basal liquid medium kept under shaking.

Thidazuron was also tried in twentyone combinations with NAA, IBA (0.05, 0.1, 0.5 mg/l) and BAP (0.5, 1.0 mg/l) with 5 explants per treatment and the shoot bud proliferation was very high (1-13 buds/explant). The best response was at 0.1 mg/l TDZ and 0.1 mg/l of NAA (5.4 buds/ explant) (Table 6.7).

c) Multiple shoot induction in cotyledonary nodes

Cotyledonary nodes from 3-4 weeks old seedlings without their cotyledonary segments were cultured after the sterilization procedure on 3/4 MS supplemented with filter sterilized zeatin (0.5 - 4.0 mg/l). Multiple shoot induction was observed from cotyledonary node in all treatments. The best response was in zeatin (0.5 mg/l) with 6-8 axillary buds/explant (Table 6.8).

When cotyledonary nodes along with their expanded cotyledons were excised from *in vitro* raised seedlings and cultured on MS medium supplemented with 2.2 mg/l of BAP and 0.2 mg/l of IBA, multiple shoot induction (4-8/explant) were observed initially. By sub-culturing these shoots on same medium repeatedly as many as 60 shoots could be obtained in a span of 3 months.

Table6.6 : Effect of thidiazuron on shoot bud proliferation (seedling explant).

Media	% explants showing shoot bud proliferation	No. of axillary buds/ explant
3/4 MS + Thidiazuron (0.05 mg/l)	57.1	1 - 3
3/4 MS + Thidiazuron (0.1 mg/l)	85.7	1 - 5
3/4 MS + Thidiazuron (0.5 mg/l)	83.3	1 - 4
3/4 MS + Thidiazuron (1.0 mg/l)	66.6	1 - 4
3/4 MS + Thidiazuron (2.0 mg/l)	55.5	1 - 4

Table 6.7 : Effect of thidiazuron (TDZ) in combination with other hormones on shoot bud proliferations.

$^3/_4$ MS Medium with	Explants showing response (%)	No. of buds / explant (Range)	Mean number of shoot buds / explant
TDZ (0.1 mg/l)	100	1-8	4.2
TDZ (0.1 mg/l) + BAP (0.5 mg/l)	100	1-9	4.0
TDZ (0.1 mg/l) + BAP (1.0 mg/l)	100	1-6	3.8
TDZ (0.1 mg/l) + NAA (0.05 mg/l)	80	1-5	2.4
TDZ (0.1 mg/l) + NAA (0.1 mg/l)	100	1-13	5.4
TDZ (0.1 mg/l) + NAA (0.5 mg/l)	80	2-7	3.2
TDZ (0.1 mg/l) + IBA (0.05 mg/l)	100	2-8	4.4
TDZ (0.1 mg/l) + IBA (0.1 mg/l)	100	2-8	4.2
TDZ (0.1 mg/l) + NAA (0.5 mg/l)	100	1-6	3.2
TDZ (0.1 mg/l) + BAP (0.5 mg/l) + NAA (0.05 mg/l)	100	1-4	1.6
TDZ (0.1 mg/l) + BAP (0.5 mg/l) + NAA (0.1 mg/l)	60	1-5	1.6
TDZ (0.1 mg/l) + BAP (0.5 mg/l) + NAA (0.5 mg/l)	100	1-7	2.4
TDZ (0.1 mg/l) + BAP (0.5 mg/l) + IBA (0.05 mg/l)	80	1-3	1.8
TDZ (0.1 mg/l) + BAP (0.5 mg/l) + IBA (0.1 mg/l)	80	1-6	2.8
TDZ (0.1 mg/l) + BAP (0.5 mg/l) + IBA (0.5 mg/l)	80	1-10	3.4
TDZ (0.1 mg/l) + BAP (1.0 mg/l) + NAA (0.05 mg/l)	80	2-4	2.6
TDZ (0.1 mg/l) + BAP (1.0 mg/l) + NAA (0.1 mg/l)	100	2	1.6
TDZ (0.1 mg/l) + BAP (1.0 mg/l) + NAA (0.5 mg/l)	80	1-6	2.0
TDZ (0.1 mg/l) + BAP (1.0 mg/l) + IBA (0.05 mg/l)	80	1-5	2.0
TDZ (0.1 mg/l) + BAP (1.0 mg/l) + IBA (0.1 mg/l)	100	2-5	3.4
TDZ (0.1 mg/l) + BAP (1.0 mg/l) + IBA (0.5 mg/l)	40	3	0.6

Table 6.8 : Response of cotyledonary nodes to zeatin.

Zeatin concentration (mg/l)	No. of buds per explant (range)	Mean shoot length (cm)
0.5	6 - 8	1.3
1.0	4 - 6	1.1
2.0	2 - 4	1.4
4.0	3 - 5	2.1

Decapitation of in vitro germinated seedlings on *in vitro* germination medium, resulted in 85.7 per cent of the seedlings producing multiple shoots (2-16 shoots/ seedling).

Multiple shoot induction

6.5.6 Shoot-bud elongation

Shoot-bud elongation of multiple shoot buds was tried on liquid medium containing BAP, KIN and zeatin at 2 and 5 mg/l under a shaker. The results were not satisfactory. Two semi solid medium were also tried namely : (i) Modified MS medium containing sucrose (5%), maltose (5 g/l), BAP (1 mg/l) and coconut water (10%) and (ii) Modified MS medium (Raj Bhansali, 1990) for shoot bud elongation, the latter medium showed better response with 69.9 per cent of the shoots showing elongation (Table 6.9).

6.5.7 Rooting of microshoots

a) *In vitro* rooting

Spontaneous rooting (10-30%) was observed when microshoots were cultured on hormone free half MS semi-solid medium. When microshoots were tested for rooting efficiency on semi-solid, half-strength MS medium containing 3 per cent sucrose, 1 g/l PVP-360 and NAA, IBA and IAA alone at 2.5 and 5.0 mg/l each and in combination of two at 2.5 mg/l each, the best response (50% rooting) was observed at 5.0 mg/l NAA and in NAA + IBA combination. The maximum number of roots

Table 6.9 : Elongation of shoot buds in two different media.

Bud elongation	No. of shoot buds used	No. of buds showing elongation	% of buds showing elongation
(i) $^3/_4$ MS + Org + Sucrose (5%) + Maltose (5 g/l) + BAP (1 mg/l) + Coconut water (10%)	28	6	21.4
(ii) Modified MS medium (Raj Bhansali, 1988)	29	20	68.9

formed were six and the number of days taken for rooting was 10-45 days (Table 6.10).

In vitro rooted plantlet

In another rooting trial (factorial experiment) two basal medium (MS, WPM), two state of medium (solid, liquid), two levels of sucrose (half strength and full strength) and three levels of auxins (0, 5 mg/l NAA and 2.5 mg/l each of NAA and IBA in combination) were tested for rooting efficiency in microshoots of H 4-7. The results showed that WPM medium with 1per cent sucrose was best for root induction (80%). Levels of sucrose and concentration of salt had significant effect on rooting. Rooting was more in liquid medium supplemented with half the level of sucrose. When microshoots of VRI-2 cotyledonary node were pulsed with either in 10 mM NAA or 10 mM IBA and cultured on hormone free half MS solid medium containing 0.2per cent AC, the best rooting (60%) was in treatment with 10 mM NAA.

Table 6.10: In vitro rooting of microshoots

Medium	% shoots rooted	No. of roots	Root length (cm)	Duration for rooting (days)
$^1/_2$ MS + NAA (2.5 mg/l)	12.5*	6	3.0	10
$^1/_2$ MS + NAA (5.0 mg/l)	50.0	5	4.5	10-40
$/_2$ MS + IBA (2.5 mg/l)	12.5	1	3.0	25-30
$^1/_2$ MS + IBA (5.0 mg/l)	12.5	1	3.0	25-30
$^1/_2$ MS + IAA (2.5 mg/l)	12.5	1	4.5	45
$^1/_2$ MS + IAA (5.0 mg/l)	12.5	1	3.5	25-30
$^1/_2$ MS + NAA (2.5 mg/l) + IAA (2.5 mg/l)	12.5	2	3.5	30
$^1/_2$ MS + NAA (2.5 mg/l) + IBA (2.5 mg/l)	50.0	2	4.5	10-20
$^1/_2$ MS + IAA (2.5 mg/l) + IBA (2.5 mg/l)	50.0	3	4.0	20

* Average of eight shoots

b) *Ex vitro* rooting

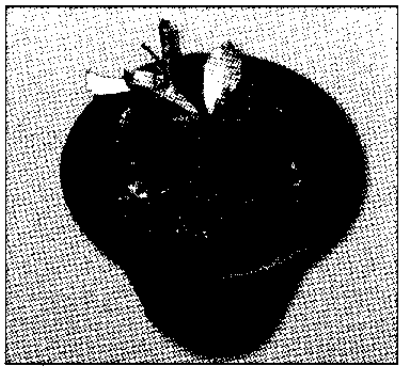
Ex vitro rooting was observed at a low frequency (12.5%) when microshoots were given slow dip in either NAA or IAA at 250 ppm for 48 h in dark and potting them in mixture containing 1:1:1 soilrite, sand and coconut pith and irrigating with a dilute 1/5 MS salt nutrient solution containing 2 mg/l of IBA resulted in *ex vitro* rooting after 6-8 weeks.

6.5.8 Hardening and acclimatisation

The *in vitro* rooted plantlets were hardened first on half-strength MS liquid medium containing 1.5 per cent sucrose and then on the same medium without sucrose for 2-3 weeks in each medium. In liquid medium the roots got elongated. One of the roots was prominent and behaved like tap root. After in vitro hardening the plantlets were transferred to plastic pots (4") containing different proportion of sand, soilrite and coir-pith. The pots were initially covered with thick gauge polybags and perforations were made later to reduce the humidity. Irrigation was done with sterile distilled water and 1/10 MS salt solution. Pot mixture containing 2:1 of sand and soilrite gave maximum survival (>90%). After 4-6 weeks of hardening in pots under laboratory condition, the plantlets were transferred to 8" earthern pots containing 1:1:1 of red earth, sand and compost and housed in green house under partial shade and provided with drip irrigation. The survival of plants in green house was 100 per cent and leaves of micro propagated plants got changed into normal morphology (obvate). After 4-6 months in green house the micro propagated plants were found to be fit for field planting. The time requirement for different stages of micropropagation varied. From explanting stage to potting stage, 38 to 52 weeks were required (Table 6.11).

Table 6.11 : Duration involved in different stages of micropropagation.

Stage of micropropagation (nodal culture) - seedling origin	Approximate duration (weeks)
Raising of *in vitro* seedlings	4 - 6
Establishment and multiplication of shoot buds	6 - 8
Shoot bud elongation	6 - 8
In vitro rooting	4 - 6
In vitro acclimatisation	6 - 8
Establishment in pots	10-12



Potted micropropagated plantlet

6.5.9 Studies on VAM

Four species of vesicular arbuscular mycorhiza (VAM) could be isolated from native cashew soils of different locations in NRCC, Kemminje, NRCC, Shantigodu and Kundapur. They were *Scutellospora nigra, Glomus multicaule, G. macrocarpum and G. australe.* Of these *Scutellospora nigra* and *Glomus macrocarpum* were the predominant species. Roots of cashew trees were examined for VAM infection. Staining with trypan blue indicated the presence of vesicles and arbuscules in all the cashew roots.

Spores of *Scutellospora nigra* was isolated and cultured on cashew seeds on sterile native soil as culturing on sorghum seeds with soil-rite medium inhibited the growth of the spore, to produce monocultures. Micro propagated plants were inoculated with 50 g of the soil containing an inoculum load of 60-80 spores along with control plants in sterile soil without VAM.The survival and influence of VAM on growth of plants were observed. Preliminary studies showed than VAM did not have any significant influence on the survival of micropropagated plant. Moreover the control plant showed an increase in the height over the inoculated plants. The initial lag phase in growth of VAM-inoculated plants has been reported by many workers. The influence of VAM on the growth and survival of micropropagated plants at a later stage in the field has to be studied.

6.5.10 Field planting and evaluation of micro propagated plants

During August 1997, a set of twentynine micro propagated plants of 4 varieties along with 4 plants of control (grafts) were closely planted (4m x 4m). All the plants got established and their growth was vigorous. One year after planting root-biomass in dwarf genotype was studied following sectorial method. The root biomass of micro propagated plants was 5 times that of grafted plant (Table 6.12). In micro propagated plant, the lateral root system was predominant while in grafted plant, though tap root was present its lateral root-system was poor.

Table 6.12 : Root-mass of micro propagated plant and control (1 year after planting).

Plant type	Root density (g/m^3 soil)		
	Thick roots	Thin roots	Total
Tissue culture	53.42	38.26	91.68
Grafted plant	10.50	7.82	18.32

In the first year after planting, 1/3 of the TC plants flowered and in the second year, 60 per cent of the plants showed flowering and 2 micro propagated plants of VRI-1 had full bearing of fruits. The flowering and fruiting behaviour was normal.

Micropropagated plant in the field

Subsequently a second trial with micro propagated plants was laid out during 1999. Here twenty micro propagated plants each of H-4-7 and VRI-2 were planted along with their grafts as control following CRD with 5 replications and 4 plants per plot and a spacing of 5m x 5m. The micro propagated plants showed 100 per cent establishment and showed a promise of better growth than their counter parts.

6.5.11 Axillary shoot bud proliferation in explants of mature tree origin

Axillary shoot bud proliferation in nodal cultures of Ullal-2 and NRCC-1 was attempted by culturing them on three basal media namely MS, WPM and SH supplemented with two levels of TDZ (0.1 and 2.0 mg/l) along with a common level of 0.1 mg/l of IBA. Multiple shoots (1-5 buds/explant) were induced in both in about 4-5 weeks. The best combination was MS with 0.1 mg/l TDZ and 0.1 mg/l IBA with 75 per cent of the explants responding.

In another trial eleven media combinations were tried using half MS as basal medium and supplementing with BAP, TDZ alone and in combination at three levels each along with a common level of 2 mg/l GA_3 and 0.1 mg/l IBA for multiple shoot induction. Multiple shoot bud induction (1-9 buds/explant) was observed in medium containing 0.5 mg/l TDZ. However, the best

response (75%) was in medium with 0.1 mg/l TDZ and 2 mg/l BAP with 1-5 shoot-buds/explant (Table 6.13). The multiple shoot induced remained stunted or failed to elongate on hormone free medium or MS medium containing GA_3. Single shoots of mature tree origin failed to root on MS medium with IBA or NAA.

Table 6.13 : Multiple shoot induction in nodal cultures.

$^1/_2$ MS with (mg/l)	No. of explants with multiple shoots (%)	No. of axillary shoot buds per explant (range)
TDZ (0.1) + GA_3 (2.0) + IBA (0.1)	0	0
TDZ (0.5) + GA_3 (2.0) + IBA (0.1)	50	1-9
TDZ (0.1) + GA_3 (2.0) + IBA (0.1)	50	1-2
BAP (0.5) + GA_3 (2.0) + IBA (0.1)	0	0
BAP (2.0) + GA_3 (2.0) + IBA (0.1)	25	2
BAP (2.0) + GA_3 (2.0) + IBA (0.1)	0	0
TDZ (0.1) + BAP (0.5) + GA_3 (2.0) + IBA (0.1)	50	2-3
TDZ (0.1) + BA) (1.0) + GA_3 (2.0) + IBA (0.1)	25	3
TDZ (0.1) + BAP (2.0) + GA_3 (2.0) + IBA (0.1)	75	1-5
GA_3 (2.5)	0	0

6.5.12 Regeneration through organogenesis

Callus from internode, leaf and cotyledon was induced in dark on a modified MS medium containing half the level of major nutrients, 6 per cent sucrose, 8 g/l agar, PVP-40,000, 0.5 - 4.0 mg/l 2,4-D with or without BAP (0.1- 1 mg/l). At 0.5 mg/l of 2,4-D no callus was observed and it increased with concentration of 2,4-D and maximum (90%) being at 4.0 mg/l 2,4-D with 1 mg/l BAP.

Leaf segments excised from one month old seedlings and when the leaves are tender viz., light yellow to pink stage were cultured. The initiation of callus from leaf segments was slow and started first on midrib and then on the cut surfaces. The percentage of callus induction varied from 6.9 to 49.8 per cent and it was maximum at 2 mg/l 2,4-D. Mature cotyledonary segments induced callus and rhizogenesis on similar medium. Culture of internode and epicotyl segments on modified MS medium with NAA

(1-8 mg/l) and NAA (1-8 mg/l) + BAP (0.5 gm/l), resulted in no callus induction. However, rhizogenesis was common at 4 and 8 mg/l NAA.

6.5.13 Regeneration through embryogenesis

a) Nucellus culture

Developing nuts (3-4 weeks old) of V-5 and VRI-2 were sterilized and dissected out to extricate ovules. The ovules were bisected and embryos were removed. The bisected ovules or only nucellus tissue carefully removed from ovule cavity were inoculated on to MS medium modified to contain half strength major nutrients, 6 per cent sucrose, 400 mg/l L-glutamine, PVP-40,000, agar (8 g/l) and supplemented with 2,4-D (0.5 - 4.0 mg/l). Callus was observed in dark and subsequently embryogenic structure was observed in only small percentage of explants. Embryogenic structures were sub-cultured on 0.5 mg/l 2,4-D + BAP (0.5 - 1.0 mg/l) and also on medium with NAA (0.1 mg/l) + BAP (0.5 - 1.0 mg/l). In the latter, green shoot bud got differentiated without elongation. These on further transfer to liquid hormone free medium resulted in green leaf and root differentiation.

In another experiment with nucellar tissue excised from 3-4 week old nuts after pollination and inoculating on to above modified MS medium with 2,4-D (0.5 - 4.0 mg/l) and kept in 16/8 light-dark cycle, callus was observed in 0.5 - 1.0 mg/l 2,4-D. The calli on transferring to medium containing 0.5 mg/l 2,4-D and BAP (1- 2 mg/l) turned friable. Multiplication of these calli was observed in medium containing 0.1 mg/l of 2,4-D and 2-4 mg/l of BAP. Sub-culturing of callus on medium with 1 mg/l NAA/IAA + zeatin (1 mg/l) the calli grew profusely and was still friable. Only on medium with 0.5 mg/l 2iP + CW (15%) globular structures appeared. These on ABA (0.1, 0.5 mg/l) medium resulted in improper germination with predominance of root system and poor development of shoot.

b) Immature cotyledon culture

Immature cotyledonary segments excised from 4 to 5 weeks nuts of H 2/11 and H 3-4 were cultured on MS medium

supplemented with PVP 40,000 (1 g/l), BAP (1 mg/l), 2,4-D (1 mg/l), NAA (5 mg/l) and coconut water (10%) in 5 different combinations. Culturing of cotyledonary segments initially in dark for one month and later in 16/8 photo-period resulted in embryogenesis (5.8 to 8.3%). In medium containing 2,4-D, callus formation always preceded embryogenesis. From brown callus , white embryogenic structures appeared. Direct embryogenesis was observed when 2,4-D was deleted in the medium but in the presence of BAP, NAA and CW. In H 4-7, medium containing 1 mg/l each of BAP and 2,4-D in combination induced embryogenesis. Somatic embryoids upon separation and culture on ABA medium (0.1 and 0.5 mg/l) resulted in improper germination with predominance of root system and fasciated shoot development (Table 6.14).

Table 6.14 : Induction of embryogenesis in mature cotyledonary segments of cashew.

MS Medium with	Embryogenesis	
	Frequency	Percentage
BAP (1 mg/l) + 2,4-D (1 mg/l) + NAA (5 mg/l) + CW (15% v/v)	2/34	5.8
BAP (1 mg/l) + NAA (5 mg/l) + CW (15% v/v)	1/13	7.6*
BAP (1 mg/l) + NAA (5 mg/l) + 2,4-D (1 mg/l)	0/23	0.0
BAP (1 mg/l) + 2,4-D (1 mg/l)	2/24	8.3
BAP (2 mg/l) + IAA (2 mg/l)	0/24	0.0

* Direct embryogenesis without callus

6.6 Summary

A full fledged tissue culture facility was set up. Various explants of cashew excised from *in vitro* raised seedlings as well as lab raised seedlings were cultured aseptically on various semi-solid medium. For initiation and establishment of nodal cultures of seedling origin Murashige and Skoog's (1962) (MS) medium modified to contain 3/4 strength salts, 3 per cent sucrose and 1g/l activated charcoal (AC) solidified with 0.8 per cent agar was found ideal. Axillary

shoot-bud proliferation (1-13 shoot buds/ explant) was obtained when nodal cultures established were re-cultured on the above basal medium with 1 g/l PVP-360, 2.25 g/l phytagel containing thidiazuron (TDZ) alone and in combination with other plant growth regulators (BAP,NAA and IBA). Multiple shoots on subculture to hormone free medium viz., Raj Bhansali's medium (1990) resulted in elongation of shoots. Microshoots generated showed rooting by both ex vitro method and *in vitro* methods. However, rooting was maximum (50-80%) when cultured on half MS medium containing NAA alone (5 mg/l) or NAA+IBA at 2.5 mg/l each. Rooted plantlets were successfully hardened both *in vitro* and *ex vitro* (pot stage) conditions and field planted. Establishment of tissue culture plants in greenhouse and field was maximum. In field, tissue culture plants were found to be vigorous, strong in lateral root-system and showed normal flowering and fruiting behaviour.

In contrast to seedling explants, nodal explants established from young cashew grafts and field grown trees were found to be highly prone to contamination and showed reduced response. It was dependent on season, type and source of explant. Half-MS medium supplemented with glutamine (400 mg/l), AC (2 g/l), 2.25g/l phytagel was found suitable for initiation. The above basal medium containing PVP-360 (1 g/l) instead of AC and in presence of TDZ alone or in combination with BAP, GA3 (0.5-2 mg/l) and IBA (0.1 mg/l) inducted multiple shoot buds (1-9 buds/plant).

Callus could be induced in dark from internode, leaf and cotyledonary explants on half- MS medium containing 2,4-D with BAP. Only leaf and cotyledonary callus was regenerative. From nucellus callus and immature cotyledonary callus, embryogenesis was observed in a small percentage of explants. Germination of somatic embryos was not satisfactory as it resulted in predominance of roots and poor shoot bud differentiation.

7. EDUCATION AND TRAINING

7.1 Training

One training programme each on cashew production technology, vegetative propagation of cashew and utilization of cashew apple for farm women were conducted during the year. Four trainees sponsored by Karnataka Cashew Development Corporation (KCDC) and Department of Agriculture, Maharashtra participated in the training programme on cashew production technology in which recent technologies developed on all aspects of cashew production were explained to the trainees. In the training programme on vegetative propagation of cashew, 6 grafters sponsored by Andhra Pradesh Forest Development Corporation and Bharatiya Agro Industries Foundation, Tiptur were trained on softwood grafting technique. In the training programme on utilization of cashew apple for farm women eighty farm women from Kerala were trained regarding the preparation of juice, jam and chutney from cashew apples.

8 LINKAGES / COLLABORATION

- In collaboration with UAS, Bangalore, thirtythree released varieties and a TMB tolerant accession were DNA finger printed.
- In collaboration with NRC for DNAFP, nineteen accession from NCGB were DNA finger printed.
- In collaboration with PDBC, Bangalore, cashew bark and frass extracts / volatiles have been evaluated for response induction by EAG.
- Soil and water conservation campaign and plant protection campaigns were conducted in collaboration with the Department of Agriculture, Kerala and Directorate of Cashewnut and Cocoa Development (DCCD), Kochi.
- Training programme on utilization of cashew apple was organized in collaboration with KVK of CPCRI, Kasaragod, Department of Agriculture, Kerala and Regional Centre, CFTRI, Mangalore.
- Annual Cashew Day was organized in collaboration with DCCD, Kochi.
- Demonstration plots laid out in association with Sri. Kshetra Dharmasthala Rural Development Organisation were also monitored during the year.

9. AICRP CENTRES

Headquarters

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

University centres

1. Cashew Research Station
(Acharya NG Ranga Agricultural University)
Bapatla - 522 101, Guntur Dist.,
Andhra Pradesh.
Phone No. (08643) - 24052, 25098.

2. Cashew Research Station
Department of Agriculture
(Orissa University of Agriculture and Technology)
Bhubaneswar - 751 003, Orissa.
Phone No. (0674) - 402669.

3. Agricultural Research Station
(University of Agricultural Sciences)
Chintamani - 563 125, Kolar District,
Karnataka.
Phone No. (08154) - 52118, 50420.

4. Zonal Agricultural Research Station
(Indira Gandhi Krishi Vishwa Vidyalaya)
Jagdalpur - 494 005,Kumharawand, Bastar District,
Madhya Pradesh.
Phone No. (07782) - 36301, 23360.

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

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

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

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

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

10. GENERAL INFORMATION

10.1 List of Publications

10.1.1 Research/Popular Publications

Bhaskara Rao, E.V.V. 1999. Cashew Scenario and National Perspective for Research and Development. Invited article for the Souvenir on National Cashew Show - RFRS (KKV), Vengurle, Maharashtra, 10-12 April 1999.

Bhat, M.G., Bhaskara Rao, E.V.V., Uma Raghunathan and Thimmappaiah. 1999. Kaju ki Nayi Kisme (Hindi) (New varieties of cashew) *Krishi Chayanika*. 48-54. Jan-Mar, 1999.

Korikanthimath, V.S., Ankegowda, J., Yadukumar, N., Rajendra Hegde and Hosmani, M.M. 1999. Micro-climatic and physiological characteristics of robusta coffee, cardamom, Coorg mandarin and Pepper in mixed cropping system. *Indian Journal of Agronomy*. 44(2):289-293.

Nampoothiri, K.U.K., Kumaran, P.M., Jerard, B.A., Ratnambal, M.J., Bhaskara Rao, E.V.V. and Parthasarathy, V.A. 1999. Combining ability in coconut. (*Cocos nucifera* L.). CORD. XV(2):68-75.

Sreenath Dixit, Swamy, K.R.M., Yadukumar, N. and Bhaskara Rao, E.V.V. 1999. Field demonstrations : Role in promoting cashew production technology. *The Cashew*. 13(2):11-17.

Sundararaju, D. 2000. Foraging behaviour of pollinators on cashew. *The Cashew* (In press).

Thimmappaiah, Putra, G.T. and Shirly Raichal Anil. 1999. In vitro grafting of cashew (*Anacardium occidentale* L.). *Scientia Hortic.* (In press).

10.1.2 Papers presented in Symposia / Workshop / Seminar

Bhat, M.G. and Bhaskara Rao, E.V.V. 1999. Review of performance of cashew varieties in different agro-ecological regions of India. In: XIV Biennial workshop of AICRP on Cashew at OUAT, Bhubaneswar, 28-30 October 1999.

Nayak, M.G. and Tangaraj, T. 2000. Influence of preharvest bunch covering with black polybag on post harvest quality of banana cv. Robusta. **In:** National seminar on recent advances in Plant Biology - An interdisciplinary approach to unravel plant functions. CPCRI, Kasaragod, 3-5 February, 2000.

Swamy, K.R.M. 2000. Research achievements in cashew. Presented in district level cashew seminar, Kasaragod, 26 February 2000.

Yadukumar, N. and Balasimha, D. 2000. Effect of drip irrigation and fertilizer levels on photosynthesis in cashew. **In:** National seminar on recent advances in Plant Biology - An interdisciplinary approach to unravel plant functions. CPCRI, Kasaragod, 3-5 February, 2000.

10.1.3 Book / Chapters

Bhat, M.G., Bhaskara Rao, E.V.V. and Swamy, K.R.M. 1999. Genetic resources of cashew and their utilization in crop improvement. **In:** Improvement of plantation crops (compiled and edited by Ratnambal, M.J., Kumaran, P.M., Muralidharan, K., Niral, V. and Arunachalam, V.). CPCRI, Kasaragod, Kerala, India. Pp.91-98.

Bhaskara Rao, E.V.V. 1999. Cashew development - A Futuristic Approach. **In:** Improvement of plantation crops. (compiled and edited by Ratnambal, M.J., Kumaran, P.M., Muralidharan, K., Niral, V. and Arunachalam, V.). CPCRI, Kasaragod, Kerala, India. Pp.86-90.

10.1.4 Technical Reports / Bulletins / Compendia

National Research Centre for Cashew. 1999. Annual Report 1998-99. Puttur, Karnataka. 150 pp.

All India Coordinated Research Project on Cashew. 1999. Annual Report 1998-99. National Research Centre for Cashew, Puttur, Karnataka. 136 pp.

National Research Centre for Cashew. 1999. Cashew News. Newsletter No.1. Vol.4. Puttur, Karnataka.

National Research Centre for Cashew. 1999. Cashew News. Newsletter No.2. Vol.3. Puttur, Karnataka.

National Research Centre for Cashew. 2000. Research Highlights 1999-2000. Puttur, Karnataka. 17p.

10.1.5 Extension bulletins / pamphlets (in Kannada)

Bhat, P.S. and Sreenath Dixit. 2000. Doubts in cashew cultivation and their solutions (revised) 22p.

Bhat, P.S. 2000. Information booklet. 18p.

Bhat, P.S. 2000. Farmers' experience in cashew growing. 5p.

Bhat, P.S. and Shirly Raichal Anil. 2000. Cashew apple preparations. 4p.

10.2 List of ongoing research projects

Project No.	Project Title	Project leader/ associate
	CROP IMPROVEMENT	
1.1	Collection, conservation, cataloguing and evaluation of cashew germplasm	KRM Swamy MG Bhat PS Bhat KV Nagaraja
Ad-hoc Scheme	Network programme on collection of cashew germplasm from east coast and west coast regions of India	MG Bhat EVV Bhaskara Rao KRM Swamy U Vishukumar H Yajnesh
1.2	Varietal Improvement of Cashew	MG Bhat KRM Swamy KV Nagaraja
1.3	Tissue culture studies for micropropagation and somaclonal variation	Thimmappaiah Shirly R. Anil
DBT Scheme	In vitro regeneration of cashew from mature tree explants	Thimmappaiah Shirly R Anil, Putra, G. Sadhana P Hebbar
	CROP MANAGEMENT	
2.2	Planting systems and spacings trials in cashew	N Yadukumar
2.3	Canopy management studies in cashew	MG Nayak N Yadukumar
2.7	Integrated nutrient management for sustainable production of cashew	N Yadukumar
2.8	Efficacy of soil and water conservation with organic manuring in cashew garden grown in slopy areas	N Yadukumar
2.9	Root stock scion interaction in cashew	KRM Swamy MG Nayak

Project No.	Project Title	Project leader/ associate
	CROP PROTECTION	
3.4	Integrated pest management of cashew stem and root borer (CSRB)	TN Raviprosad PS Bhat D Sundararaju KV Nagaraja
3.5	Integrated pest management of tea mosquito bug (TMB)	D. Sundararaju PS Bhat TN Raviprosad
	POST HARVEST TECHNOLOGY	
4.4	Functional properties of defatted cashew kernel meal	KV. Nagaraja
Ad - hoc Scheme	Value addition in cashew	KV Nagaraja MS Mahesh
	TRANSFER OF TECHNOLOGY	
5.1	Research cum demonstration plots	Sreenath Dixit (till 10.9.1999) PS Bhat

10.3 RAC, Management Committee, SRC, QRT meetings etc. and significant decisions.

10.3.1 Research Advisory Committee

1. Dr. K.V. Ahamed Bavappa, FAO Consultant — Chariman
   Karooth Villa, P.O. Kappur,
   Kumaranellur - 679 552
   Palakkad District, Kerala
   Phone : 0492-676066 (R) / 676322 (O)

2. Dr. R.T. Gunjate — Member
   Reliance Petroleum Limited
   Horticulture Department
   E.O.2, Township,
   Motikhavadi 361 140
   Jamnagar District (Gujarat)
   Phone : 0288-519841 (O) / 557959 (R)

3. Prof. A. Regupathy — Member
   Professor of Entomology
   AC & RI, Coimbatore 641 003
   Phone : 0452-822956 / 822960 (R)

4. Mr. P.P. Balasubramanian — Member
   Director
   Directorate of Cashewnut and Cocoa Development
   Govt. of India
   Ministry of Agriculture, (Dept. of Agri. Cooperation)
   8th Floor, Kera Bhavan, Kochi 682 011, Kerala
   Phone : 0484-351751, 373239 (O) / 777155 (R)

5. Dr. B.R. Hegde — Member
(Retired Director of Research)
347, 10th Main, 7th Cross, NTI Layout
Vidyaranyapura
Bangalore - 560 097
Phone : 080-8380716 (R)

6. Mr. Md. Alai Baig — Member
Village Garare, Via Jale
Dist. Darbhanga, Bihar
Phone : 06247-74274 (R)

7. Sri. Shashikant Chaudhury — Member
Village Brahmpur, PO Ratanpur
Dist. Darbhanga, Bihar - 847 307
Phone : 06247-85278 (R)

8. Dr. R.N. Pal — Member
Asst. Director General (PC)
Indian Council of Agricultural Research
Krishi Bhavan
New Delhi - 110 001
Phone : 011-3381748 (O) / 6241523 (R)

9. Dr. E.V.V. Bhaskara Rao — Member
Director
NRC-Cashew, Puttur - 574 202
Phone : 08251-21530 (O) / 20992, 23592 (R)

10. Dr. K.R.M. Swamy — Member-Secretary
Principal Scientist (Hort.)
NRC-Cashew, Puttur - 574 202
DK, Karnataka
Phone : 08251-20902 (O) / 23422 (R)

Significant Decisions:

- DNA extraction facility to be created in the tissue culture lab at NRCC. Dr. Thimmappaiah / Mrs. Shirly Raichal Anil may visit NRC-DNAFP, New Delhi and UAS, Bangalore for doing the DNA finger printing. If needed, 2-3 extended visits may be made to these centres.
- Cashew apple has corrosive principles, phenolic compounds and organic acids which make the cashew apple not readily palatable. The corrosive principles in cashew apple are to be determined for the core collections by Dr.K.V.Nagaraja.
- Indigenous collection numbers (IC No.) obtained from NBPGR for cashew germplasm accessions conserved in NCGB, Puttur may be sent to all the coordinating centres for reference.
- In order to exploit the locked up variability, large scale crossing of distantly related accessions may be taken up for which a net worked project involving coordinating centres may be prepared and submitted to ICAR for funding.
- As the CSRB is a major threat in cashew cultivation, conditions beyond which the infested tree is not going to recover if treatment is taken up may be indicated. Visible symptoms based on which the infested tree may be cut and uprooted by the farmer should be indicated. Phytosanitation of the plantation is to be given priority.
- Use of pheromones / attractants against CSRB can lead to efficient pest management. Hence different isomers possessing aggregation pheromone properties may be evaluated against CSRB adults. The combination of different isomers may also be tried. The Malaysian Company distributing these isomers may be contacted.
- Characterization of plant volatiles (from infested bark, frass and exuded gum) in CSRB infested cashew trees may be attempted under NATP. IICT, Hyderabad may be consulted in this regard.
- Studies on smoking against TMB may be taken up as an observational trial but not as a regular project. *Acalypha* and *Vitex negundo* (notchi) may also be used to generate smoke along with other smoking material. All the trees are to be fumigated individually.
- Suitability of Singapore cherry as an alternate host to TMB may be confirmed.

- The new systemic insecticide, Imidacloprid may be evaluated against TMB in the existing trial on evaluation of new insecticides.
- Baby bits and pieces of cashew kernel are sold at lower prices. Hence, cashew butter (spread) which is rich in Vitamin E, can be prepared and possibility of using this in cosmetics be explored.
- As cashew apple is rich in Vitamin C, a one day training programme for cashew apple utilization has to be organized in collaboration with CFTRI, Regional Centre, Mangalore, for Training Associates (Home Science) of KVK. Zonal Co-ordinator, KVK, Bangalore may be consulted for finalizing the programme. This training is to be arranged besides the training programme on cashew apple utilization for farm women.
- Package for new demonstration plots should include plant protection, fertilizers, soil and water conservation, incorporation of organics etc. i.e., need based package to be suggested. Terracing and opening of catch pits may also be included.
- Training of Farm women for utilizing cashew apple which is a rich source of Vitamin C may be organized in collaboration with NRC for Women in Agriculture, Bhubaneswar.

10.3.2 Institute Management Committee (1997-2000)

.	Director NRCC Puttur	Chairman
:.	Joint Director of Horticulture (P.C.) Directorate of Horticulture Govt. of Karnataka Lalbagh, Bangalore 560 004	Member
I.	Special Secretary of Agriculture Govt. of Kerala Thiruvananthapuram 695 001	Member
..	Head, Division of Horticulture College of Agriculture UAS, GKVK, Bangalore 560 065	Member
i.	Sri Md.Alai Baig Vil: Garare, Via: Jale District Darbhanga, Bihar	Non-official member

6.	Sri Shashikanth Choudhari Vill: Brahmapur, P.O: Ratanpur Dist: Darbhanga, Bihar	Non Official Member
7.	Asst. Director General (PC) ICAR, Krishi Bhavan New Delhi - 110 001	Member
8.	Dr. KRM Swamy Principal Scientist, NRCC, Puttur	Member
9.	Sri.N.Yadukumar Senior Scientist, NRCC, Puttur	Member
10.	Sri. Thimmappaiah Senior Scientist, NRCC, Puttur	Member
11.	Dr. Sreenath Dixit Member (Till 10.9.99) Scientist (SS), NRCC, Puttur	Member
12.	Senior Finance & Accounts Officer CPCRI Kasaragod	Member
13.	Sri. K.Sanjeeva Asst.Administrative Officer NRCC, Puttur	Member-Secretary

Significant decisions

The committee met twice during the year and assessed the progress of research projects and ac-hoc projects. It also accorded approval for the purchase of equipments.

10.3.3 Significant decisions of Twelfth Staff Research Council Meeting held on 6-7 May 1999.

- In the cases where only one accession is included in a cluster, the survey has to be repeated in the region from where the collection is made.
- Ullal-1 and NRCC Sel-1 having extended flushing period may be utilized for host enrichment technique of egg parasitoids of TMB.
- The varieties in pipeline should be tested for adherence of testa to the kernels and this will be one of the criteria for recommendation for release.
- VAM studies to be continued to confirm its usefulness in hardening of tissue culture plants.
- In planting systems and spacing trials, addition and removal of nutrients may be estimated for monitoring nutrient budgeting biannually.
- In integrated nutrient management studies, instead of all types of organic manures, only one organic manure at different proportions may be tried.
- In soil and water conservation technique trial, mulching may be provided for all the treatments.
- For work on volatiles attracting CSRB adults (kairomones) the requisite information may be obtained from IIHR and PDBC, Bangalore.
- Survey on natural enemies especially for egg parasitoids of CSRB may be intensified.
- Population dynamics may be recorded for developing prediction models for CSRB.
- Evaluation of new insecticides against TMB may be restricted.
- Evaluation of efficacy of smoking against TMB may be taken up.
- Survey on other host plants / harbouring plants of TMB during flushing may be located and exploited for host enrichment technique (HET).

- Life table studies of TMB in the field may be done.
- Work on functional properties of defatted kernel flour should be with reference to specific product.
- The butter extracted from cashew kernel bits may be compared with butter extracted from almond, cocoa and soybean.
- Technology developed should be repeated, reassessed and refined before releasing for adoption by farmers.

10.3.4 Institute Joint Council (IJC)

Official side

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

Staff Side

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

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

10.3.5 राजभाषा

राजभाषा कार्यान्वयन समिति

डॉ. ई. वी.वी. भास्कर राव	अध्यक्ष
डॉ. श्रीनाथ दीक्षित	सदस्य (दि 10.9.1999 तक)
डॉ. टी. एन. रविप्रसाद	सदस्य
डॉ. के. वी. नागराज	सदस्य
श्री. मुरलीकृष्णा एच.	सदस्य
श्री. प्रकाश वी. आंबेकर	सदस्य (दि 25.6.1999 तक)
श्री. प्रकाश जी. भट्ट	सदस्य
श्री. शेखर नायक	सदस्य
श्री. उमानाथ के.	सदस्य
श्री. उमानाथ शेट्टी	सदस्य
श्री. अन्नु के.	सदस्य
श्री. सुंदरा	सदस्य
कु. लीला एम.	सदस्य
श्री. के. संजीवा	सचिव/संयोजक

राजभाषा कार्यान्वयन - गतिविधियाँ एवं प्रगती

केन्द्र में इस वर्ष के दौरान कार्यान्वयन समिति की चार बैठकें आयोजित की गयी। अप्रैल 1999 में समिति का पुनर्गठन किया गया और चार नये सदस्यों को शामिल किया गया। हर एक बैठक में राजभाषा प्रगती और कार्यान्वयन संबंधी विषय पर चर्चा की गयी और लिएगए निर्णयों पर अमल भी किया गया।

केन्द्र में राजभाषा स्वर्ण जयंति वर्ष के उपलक्ष्य में कार्यक्रमों को विशेष उत्साह से मनाये गए। दि. 14.09.99 से 28.09.99 तक आयोजित हिन्दी परवाडा में अनेक स्पर्धाओं का आयोजन किया गया। इस वर्ष विशेष रूप से नगर में स्थित अन्य कार्यालयों से भी कर्मचारी स्पर्धाओं में भाग लिए।

जिन कर्मचारियों को हिन्दी में कार्यसाधक ज्ञान नहीं है ऐसे कर्मचारियों को केन्द्र में ही कक्षा चलाने की योजना की गयी है।

10.4 Participation in Symposia / Conferences / Seminars / Meetings

Dr. K.R.M. Swamy Dr. Sreenath Dixit Shri. N. Yadukumar	The first All India Cashew Show and seminar, RFRS, Vengurle, Maharashtra	10-12 April 1999
Dr. E.V.V. Bhaskara Rao	Inauguration of ATIC Centre and Phytonet Laboratories, IISR, Calicut, Kerala	18 April 1999
Dr. K.R.M. Swamy	Executive Committee Meeting of ISPC, CPCRI, Kasaragod	4 May 1999
Dr. E.V.V. Bhaskara Rao	Staff Research Council Meeting, NRC Oil Palm, Palode	21-23 May 1999
Dr. E.V.V. Bhaskara Rao	Summer school on crop improvement of plantation crops, CPCRI, Kasaragod, Kerala	8 June 1999
Dr. E.V.V. Bhaskara Rao Dr. K.R.M. Swamy Dr. Sreenath Dixit Sri. N. Yadukumar	Cashew demonstration farmers meeting, NRCC, Puttur	15 July 1999
Dr. E.V.V. Bhaskara Rao	Meeting of Directors of ICAR Institute / Horticulture Division meeting to finalise NATP	7-8 September 1999
Dr. K.R.M. Swamy	Meeting of the high powered committee of ICAR to review the syllabus for ARS/SRF/NET, IVRI, Bangalore	22 September 1999
Dr. E.V.V. Bhaskara Rao	Standing Committee Meeting of PLACROSYM-XIV, Sugarcane Breeding Institute, Coimbatore	1 October 1999
Dr. K.V. Nagaraja	Meeting convened by DCCD, Cochin for fixing standards for raw cashewnuts NRCC, Puttur.	15 October 1999
Dr.E.V.V. Bhaskara Rao Dr. K.R.M. Swamy Dr. K.V. Nagaraja Dr. M.G. Bhat Sri. N. Yadukumar Dr. T.N. Raviprasad Sri. H. Muralikrishna	XIV Biennial Workshop of All India Coordinated Research Project on Cashew, OUAT, Bhubaneswar	28-30 October 1999

Continued

Dr. Thimmappaiah	International conference on Biotechnology for sustainable productivity in agriculture, jointly organized by International Life Sciences Institutions, India, DBT of GOI at Hyderabad.	1-2 November 1999
Dr. K.R.M. Swamy	Executive Committee meeting of ISPC, Coconut Development Board, Cochin	18 November 1999
Dr. E.V.V. Bhaskara Rao	Meeting of Directors of Horticulture Division/Panel meeting at ICAR	14-15 December 1999
Dr. E.V.V Bhaskara Rao	Standing Committee Meeting of PLACROSYM-XIV, NRC Oil Palm, Palode	14-15 January 2000
Dr. Thimmappaiah	Improvement of spices and plantation crops through Biotechnology at IISR, Calicut	17-18 January 2000
Dr. E.V.V. Bhaskara Rao Shri. N. Yadukumar	Group meeting for fianlization of technical programmes of high density planting-cum-fertilizer trial - CRS, KAU, Madakkathara, Kerala	21 January 2000
E.V.V. Bhaskara Rao	Brain storming session on coastal eco-system programmes of NATP, CMFRI, Cochin, Kerala	29 January 2000
Dr. K.R.M. Swamy	Executive Committee Meeting of ISPC, ISRI, Calicut	31 January 2000
Dr. K.V. Nagaraja Dr. M.G. Nayak Shri. N. Yadukumar	National seminar on recent advances in plant biology - An inter disciplinary approach to unravel plant functions, CPCRI, Kasaragod	3-5 February 2000
Dr. E.V.V. Bhaskara Rao	XIV Biennial Group Meeting of AICRP on Palms, TNAU, Coimbatore	15-17 February 2000
Dr. K.R.M. Swamy Dr. P.S. Bhat Dr. T.N. Raviprasad Shri. N. Yadukumar	District level cashew seminar, Kasaragod, Kerala (jointly organised by Department of Agriculture, Govt. of Kerala; DCCD, Cochin; KAU; CPCRI, Kasaragod and NRCC, Puttur)	26 February 2000

10.5 Farmers Day/Krishimela/Exhibition/Campaigns

Shri. N. Yadukumar Dr. P.S. Bhat Dr. T.N. Raviprasad	Soil and water conservation and plant protection campaign - Sarve, Puttur taluk, Dakshina Kannada district	20 October 1999
	- Mulleria, Kasaragod district	12 November 1999
	- Kundamkuzhy, Kasaragod district, Kerala	26 November 1999
	- Adoor, Kasaragod district, Kerala	30 November 1999
Dr. E.V.V. Bhaskara Rao	Krishi Mela at CPCRI, Kasaragod	11 November 1999
Shri. N. Yadukumar Dr. P.S. Bhat	Krishi Mela and seminar on agricultural resources use challenges in next century, RRS, Brahmavar	21 October 1999
	Annual Cashew Day, NRCC, Kemminje and Experimental Station, Shantigodu	4 March 2000

10.6 Radio Talks / Interviews

Dr. K.R.M. Swamy	Sudharitha Geru Thaligalu (Improved cashew varieties), AIR, Mangalore	5 February 2000
Dr.T.N. Raviprasad	Geru beleyannu bhadisuva keetagala parinamakari nirvahane (Effective management of pests infesting cashew)	22 March 2000

10.7 Delegation / Training

10.7.1 Abroad

Dr. E.V.V. Bhaskara Rao	Two member ICAR delegation visit to Brazil to explore the possibility of ICAR, EMBRAPA Research Collaboration in the field of Horticulture	3-6 August 1999
Mrs. Shirly Raichal Anil	International training programme on Biotechnology: Micropropagation and related techniques for the improvement of crops and conservation of plant genetic resources, German Foundation for International Development, Federal Republic of Germany	18 January - 14 May 1999

10.7.2 In India

Shri. R. Arulmony	Advanced course in CDS/ISIS and WINISIS sponsored by NISSAT, New Delhi at Dr.Y.S.Parmar University of Horticulture and Technology, Nauni, Solan, Himachal Pradesh	06-15 October 1999
Mrs. Shirly Raichal Anil	Molecular techniques for DNA finger printing at NRC DNAF, NBPGR, New Delhi	29 November - 18 December 1999
Dr. P.S. Bhat	Computer application in agriculture NAARM, Hyderabad	13-24 December 1999

10.8 Awards Won

Dr. M.G. Nayak won best poster presentation award for his poster entitled "Influence of preharvest bunch covering with black polybag on post harvest quality of banana cv. Robusta". In: National seminar on recent advances in Plant Biology - An inter disciplinary approach to unravel plant function. CPCRI, Kasaragod, 3-5 February, 2000.

Dr. M.G. Nayak won Dr. J.C. Anand award for best thesis in applied and adoptive research in post harvest management in Horticultural Crops during 1999 for his Ph.D. thesis submitted to the Department of Horitculture, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu.

Dr. P.S Bhat won Dr. Abdul Kareem award for best thesis in plant protection (Entomology/Pathology/Nematology) during 1999 for his Ph.D. thesis submitted to the Department of Entomology, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu.

10.9 Distinguished Visitors

20-04-1999	Dr. C.M. Tiwari / Sri. P.K. Menon / Dr. J.P. Nowtial Hindi Committee Members
25-04-1999	Mr. B. Natarajan Managing Director KCDC, Mangalore
30-6-1999	Mr. H.H. Sahoo Chairman, OSCDC, Bhubaneswar Mr. K.K. Mohanty Managing Director OSCDC, Bhubaneswar
12-08-1999	Dr. D.P. Ray Professor and Head Dept. of Horticulture OUAT, Bhubaneswar - 751 003
17-08-1999	Mr. D.K. Pillai, IAS, Deputy Director, Small Industries Service Institute, B'lore Mr. K. Parameshwara Adiga Asst. Director SISI, Bangalore
18-08-1999	Dr. M.V.R. Prasad Mozambique
16-10-1999 (RAC Chairman and Members)	Dr. K.V. Ahamed Bavappa FAO Consultant Kumaranellur - 679 552, Kerala
	Dr. R.T. Gunjate Reliance Petroleum Limited Jamnagar District - 361 140, Gujarat
	Shri. P.P. Balasubramanian Director DCCD, Cochin - 682 011, Kerala
	Shri. Shashikant Chaudhury Ratanpur, Darbhanga District - 847 307, Bihar

Continued

	Dr. B.R. Hegde Director of Research (Retired) UAS, Bangalore - 560 065
	Dr. A. Regupathy, Professor of Entomology TNAU, Coimbatore-641 003
21-12-1999	Mr. Allum Veerabhadrappa Honourable Minister of Horticulture Government of Karnataka
29-03-2000	Dr. P. Shanta Kelath KJP Research Foundation, Trivandrum

11. PERSONNEL

Managerial

Director — EVV. Bhaskara Rao

Scientific

Discipline	Scientist	Scientist (Sr. Scale)	Sr. Scientist	Pr. Scientist	Total
Agricultural Engg. (ASPE)	S. Bhuvaneshwari (from 19.11.99)	-	-	-	1
Agricultural Entomology	-	P. Shivarama Bhat T.N. Raviprasad	D. Sundararaju	-	3
Agril. Extension	-	Sreenath Dixit (till 10.9.1999)	-	-	1
Biochemistry (Pl. Sci.)	-	-	KV Nagaraja	-	1
Biotechnology	-	-	Thimmappaiah (Gen. & Cyto.)	-	1
Computer Appl.	PD. Sreekanth (from 28.2.2000)	-	-	-	1
Genetics & Cytogenetics	Shirly R. Anil	-	-	-	1
Horticulture	Vacant	-	MG Bhat (Pl. Br.) MG Nayak (Hort. - from 21.2.2000)	KRM Swamy	4
Plant Physiology	Vacant	-	-	-	1
Soil Science	-	-	N. Yadukumar (Agron.)	-	1
Soil & Water cons. Engg.	Vacant	-	-	-	1
Total					16

Technical

Sri.K.Muralikrishna,	Farm Superintendent (T-6)
Sri.P. Abdulla,	Farm Superintendent (T-6) (from 21.7.99)
Sri.H.Muralikrishna,	Tech. Inf. officer (T-6)
Sri.A.Padmanabha hebbar,	Tech. Officer (Elec.) (T-5)
Sri.R.Arulmony,	Technical Officer (Lib.) (T-5)

Sriyuths Prakash G Bhat, N.Manikandan, R.Muthuraju, K.Seetharama (**T-4**); Prakash V. Ambekar (till 25.6.99), Lakshmipathi, R.Lakshmisha, K.V.Ramesh Babu, M.Sardar Baig, R.Shekara Naik (**T-II-3**); K.R.Padmanabhan Nair, A.Poovappa Gowda (**T-I-3**); Ravishankar Prasad, K.Babu Poojary, Bejmi Veigus, K.K.Madhavan, K.Umanath (**T-1**)

Administrative

Sri.A.Keshava Shabaraya,	Asst.Fin.& Accnts Officer
Sri.K.Sanjeeva,	Asst. Admn. Officer
Ssri.K.Jayarama naik,	Asst. Admn. Officer (from 21.3.2000)

Sri.V.Ahamed Bava (Sr.Stenographer); Sri.K.M.Jayarama Naik, (Superintendent-till 20.3.2000); Smt.B.Jayashree, Sri.O.G.Varghese (Stenographers); Sri.M.S.Satyanarayana (Assistant), Sri.K.M.Lingaraju (Sr.Clerk); Ms.M.Ratna Ranjani, Miss.Winne Lobo and Sri.Rosario Mascarenhas (Sr.Clerks-from 17.11.1999); Miss.Leela, Sri.Uma Shankar (Jr-Clerks); Sri.K.Balappa Gowda (Gestetner operator)

12. INFRASTRUCTURE DEVELOPMENT

- Construction of Guest House cum Trainees Hostel completed.
- Creation of web site of NRCC
- Nursery facilities at Kemminje strengthened.

13. MISCELLANEOUS

13.1 Graft production

During the year 1999 a total of 43,721 softwood grafts of different cashew varieties worth Rs. 6,55,815 were distributed to farmers and other development agencies. These grafts were produced under the revolving fund schemes of ICAR and DCCD which are in operation at NRCC.

During the year 1999 a total of 1,46,226 softwood grafts were prepared of which about 89,000 grafts are available for distribution during the planting season of the year 2000.

13.2 Weather data (1999 - 2000)

Months	Temperature °C		Humidity %		Total rain fall (mm)	Rainy days	Sunshine Hours	Evaporation	Wind velocity /Hour
	Max.	Min.	FN	AN					
Apr. 99	35.2	23.9	90	52	028.6	02	07	05.4	03.7
May	31.2	23.4	94	72	396.2	16	03.5	03.4	03.2
Jun.	29.5	22.9	97	80	774.2	22	04.1	03.0	03.0
Jul.	28.0	22.7	97	88	1259.6	27	01.5	01.9	04.1
Aug.	29.6	22.1	91	79	489.6	24	02.3	02.6	03.4
Sept.	31.1	22.6	94	67	141.0	14	05.3	03.8	02.5
Oct.	31.8	23.0	95	70	595.0	20	05.5	03.1	02.6
Nov.	33.5	21.4	92	51	063.4	03	07.8	03.7	02.4
Dec.	33.6	19.4	89	38	000.0	00	07.5	04.0	02.6
Jan. 2000	31.4	19.8	91	39	033.4	02	08.8	03.9	03.2
Feb.	33.9	22.3	91	41	000.0	00	07.9	04.5	02.9
Mar.	36.4	21.4	91	38	000.0	00	07.9	05.8	04.3