

ANNUAL REPORT 1993-'94



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

CONTENTS

DIRECTOR'S INTRODUCTION	(i)
CROP IMPROVEMENT	
Gen I (176) :	Collection, conservation and cataloguing and evaluation of cashew germplasm 4
Gen II :	Varietal improvement of cashew 11
Gen III :	Tissue culture studies in cashew for micropropagation and somaclonal variation 18
AGROTECHNIQUES	
Agr I(b) :	Response of high yielding varieties of cashew to different levels of nitrogen 22
Agr III(a) :	Economic feasibility of microirrigation (drip irrigation) and graded doses of NPK on the productivity of cashew 23
Agr IV :	Cashew based cropping system - inter and mixed cropping with cashew 26
Agr V :	Orchard management - Comparison of hedge and square system of planting 30
Agr VI :	Development of suitable cashew based cropping system 33
Agr VII :	Comparative efficacy of slow release nitrogenous fertilizers for cashew 36
Phy III :	High density planting of cashew 36
Hort. IV :	Studies on off-season graft production in cashew 37
Hort. V :	Root stock studies in cashew 39
Hort. VI :	Comparing the economics of top working with replanting of cashew 40
Hort. VII :	Pruning studies in cashew 42
CROP PROTECTION	
Ent. V :	Developing integrated pest management package against cashew stem and root borer 44
Ent. VI :	Biological control of tea mosquito bug and other sucking pests of cashew 47
Ent. VIII :	Testing the efficacy of plant products against tea mosquito bug, <i>Helopeltis antonii</i> Signoret 52
Ent IX :	Standardisation of mass rearing technique for cashew stem and root borer <i>Plocaederus ferrugineus</i> and investigations for attractants and pheromones 56

QUALITY ANALYSIS AND POST - HARVEST TECHNOLOGY

Biochem. I	:	Studies on biochemical changes during storage of cashewnuts and apples	62
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TRANSFER OF TECHNOLOGY

Gen. I	:	Production of parental materials and breeders' stock of cashew	66
Extn. I	:	Training extension and research workers and farmers.	68
Extn. IV	:	Research cum Demonstration plots	69
Extn. V	:	Communication behaviour and socioeconomic characteristics of cashew demonstration farmers - A study in Dakshina Kannada	70

CONCLUDED PROJECTS

Adhoc Scheme:		Screening and biochemical evaluation of cashew germplasm in relation to tea mosquito infestation	72
Hort. II(a)	:	Demonstration of beneficial effects of pruning in cashew	88

SUMMARY REPORT OF ALL INDIA COORDINATED RESEARCH PROJECT ON CASHEW

91

GENERAL INFORMATION

97

DIRECTOR'S INTRODUCTION

National Research Centre for Cashew was established in April 1986 at Puttur, Dakshina Kannada District, Karnataka. This Research Centre also serves as headquarters for All India Coordinated Research Project on Cashew, which has eight coordinating Centres under respective State Agricultural Universities in eight different states.

LOCATION

The headquarters of National Research Centre for Cashew is located 5 km away from Puttur town at Kemminje (12.45' N latitude and 75.42'E longitude) and is about 90M above MSL. It is contemplated to acquire a total area of 69.02 ha of land for laying out field experiments at Puttur, out of which 67 ha has been already acquired.

Besides the main campus at Puttur, an Experimental Station at Shanthigodu, which is 13 km away from the main campus also forms a part of this Research Centre. This Experimental Station was started as Cashew Seed farm under Central Plantation Crops Research Institute in the year 1972.

MANDATE

The National Research Centres are conceived with the idea of undertaking mission oriented research projects. The mandate of the National Research Centre for Cashew is as under:

- * Evolving high yielding varieties of cashew and breeding varieties for resistance/tolerance to pest such as tea mosquito bug.
- * Evolving varieties with high protein, lysine and other biochemical parameters.
- * Standardization of agrotechniques for achieving higher production and productivity with sustainability in view.
- * Transfer of technology to farmers and extension agencies on improved production techniques through training, demonstration and extension literature.

STAFF AND BUDGET

While establishing National Research Centre for Cashew, Puttur, 62 posts (14 scientific; 9 technical 6 administrative; 2 auxiliary and 31 supporting staff) were deployed from CPCRI. During VII Plan period, additional 14 posts (1 scientific; 5 technical; 2 administrative; 1 auxiliary and 5 supporting staff) were sanctioned. During 1990-91, six more scientific posts were deployed from CPCRI. During VIII Plan period an additional seven posts (6 administrative and 1 technical) have been sanctioned out of 34 posts approved by the PIC which brings the total staff component to 89. A total of 70 posts have been filled up. The sanctioned Budget for the financial year 1993-94 was:

	Allocation (Rs. in lakhs)	Expenditure (Rs. in lakhs)
Non-Plan	33.00	32.98
Plan	100.00	99.94
AP Cess Fund	0.84	0.84
Revolving Fund Scheme	2.69	2.69

RESEARCH ACTIVITIES

During the year a total of 25 research projects covering Crop Improvement, Agrotechniques, Crop Protection, Quality Analysis and Post-harvest Technology and Transfer of Technology were undertaken. Besides these research projects, a Revolving Fund for production of grafts is in operation. An AP Cess Fund Project on 'Screening and biochemical evaluation of cashew germplasm in relation to tea mosquito infestation' which was in operation from 1988 concluded during the year. Salient results in different research projects are as under:

Crop Improvement: Research Projects pursued under this have a common objective of evolving high yielding varieties coupled with better quality and multiple pest resistance. These objectives are contemplated to be achieved through germplasm collection, varietal improvement and screening and identification of varieties for tea mosquito tolerance.

A total of 13 trees were identified for their cluster bearing habit and medium sized nuts from West Bengal. Fifteen clonal accessions have been planted in National Cashew Gene Bank bringing the total number of accessions planted so far to 300. Under progeny trial-I, the combination H-10

(M 37/3 x T.No. 1) performed better than others in all the replications with an yield of 6.7 kg/tree/year, and cumulative yield of 23.2 kg/tree for seven years followed by H-16(1/3 Ceylon x A 18/4) with a cumulative yield of 21.4 kg/tree which was 158 percent and 138 percent more than the yield of M44/3. (control) They maintained their superiority from the first year of bearing. Among the selfed lines in progeny trial-II, yield of 3.03 kg/tree/year was recorded in S-34 (T.No.1xT. No.1) which was more than double the yield of M44/3. Among the 15 cross combinations in the progeny trial-III the highest mean yield of 6.8 kg/tree/year was recorded in H-20 (BLA-139-1xM 10/4) which was six times than that of M44/3. A total of 270 seedlings have been planted to improve the nut size in the released varieties. In the maximisation of yield plot, a yield of 382 kg/ha was recorded. M 44/3 was an higher yielder with a mean yield of 3.2 kg/tree than M 10/4. In nodal culture of seedlings MS media supplemented with 2-ip (2.5 mg/l) and NAA (0.1-1.0 mg/l) was found to enhance the shoot bud proliferation.

Agrotechniques : Research projects under agrotechniques programme contemplate to enhance the production of existing gardens by developing suitable orchard management practices. Research projects on nutritional aspects, cropping systems and orchard management are being pursued.

In an experiment on response of high yielding varieties of cashew to different levels of N, the mean yield increased with increased application of N from 250g to 750g/tree/year. Increase in net profit by Rs. 15,692/ha was observed in plot receiving the highest dose of N fertilizers (750g/tree/year) as compared to the lowest dose (250g/tree/year).

Irrigated plants showed increased growth parameters such as height, girth and canopy compared to control. The cumulative yield realised six years after planting from the plot intercropped with pineapple (33.07 kg/plot) continued to be higher than that of other plots and the yield increase was 162 percent over control plot. Soil N and P content was maximum in cashew plot with cover crop and pineapple respectively. The lowest yield was realised from the plot intercropped with acacia even after its removal. Eventhough casuarina fetched Rs. 38204/ha, as an intercrop it had affected yield of maincrop. Maintaining the plant density of 278 trees/

ha (6m x 6m spacing) gave highest yield (475 kg/ha). Cumulative yield (11 years after planting), however, was the highest (4238 kg/ha) in the case of 4m x 4m spacing (625 trees/ha).

Decapitated green scions with flower panicles, and matured scions with sprouted terminal buds could be used for soft wood grafting. In root stock studies, the height and internodal length of six month old seedlings were different between semidwarf and normal types. The cost of establishment and maintenance of top worked plot and replanted plot during past four years was Rs. 19,350 and Rs. 14,700 per ha respectively.

Crop Protection : Research projects in crop protection aim in developing integrated pest management packages against stem and root borers and effective chemical and biological control of tea mosquito and other sucking pests. Prophylactic control trial against stem and root borer (*Plocaederus ferrugineus*) was repeated at three months interval and after completion of four rounds, no incidence was recorded in commercial neem formulations (pesticides, like Nimbecidine and Limanool) compared to 8 percent in control. Among the natural enemies of tea mosquito for the first time a new egg parasitoid *Genatocerus* sp. nr. *bialbifuniculatus* Subba Rao on eggs of TMB and two reduviid predators viz. *Panthous bimaculatus* Dist. and *Sycanus collaris* (Fab.) were recorded. Attempts have been made to develop an artificial diet packet for tea mosquito bug. The life cycle and feeding potential of *Sycanus collaris* (Fab.) have been studied. Commercial neem pesticides exhibited feeding deterrence property when tested against tea mosquito bug. Studies on development of semi-synthetic diet for rearing stem and root borer in laboratory have been initiated.

Quality Analysis and Post-harvest Technology : The objective of the research project is to study the biochemical changes during storage and to arrive at suitable temperature for storage of cashew apples. During storage total lipid did not change while neutral lipid decreased initially followed by an increase. Kernel protein increased with maturity while lysine decreased. Storage of bulk nuts for more than 12 months resulted in decreased sugar, lysine and CNSL contents.

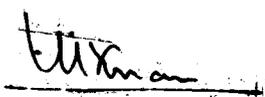
Transfer of Technology : The aim of the projects under this programme is to disseminate the technologies developed to farmers and extension agencies by conducting training programmes, distribution of planting material, bringing out extension literature and establishing demonstration plots. During the year 41,677 cashew grafts were sold with realisation of Rs. 319,168 under the Revolving Fund Scheme. A total of 46,820 successful grafts of different varieties were produced. A total of six training programmes on vegetative propagation of cashew (4) and cashew production technology (2) were conducted and a total of 97 persons including gardeners, farmers, agricultural officers, students and ARS trainees attended the courses. The trainees were from Karnataka (64); Madhya Pradesh (12); Andhra Pradesh (7); Goa (2); Kerala (5); Tamil Nadu (6) and West Bengal (1). Out of 50 demonstration plots laid out, 41 are existing and a total of Rs. 30,089 was given as subsidy under Central Sector Scheme sponsored by DCD, Cochin.

Library : The library of this Research Centre has 682 reference volumes and 380 back volumes of journals. Thirty eight Indian and 11 international journals were subscribed. During the year an amount of Rs. 1,53,692 has been spent towards strengthening the library facilities.

ABOUT THIS REPORT

This is the eighth Annual Report brought out by this Research Centre. This comprises of 25 research projects divided into five chapters namely Crop Improvement; Agrotechniques; Crop Protection; Quality Analysis & Post-harvest Technology and Transfer of Technology. Detailed results of the ongoing research projects are given followed by concluded projects and a summary of All India Coordinated Research Project on Cashew.

Puttur - 574 202
Dated October 94


(M.K. NAIR)
DIRECTOR

CROP IMPROVEMENT

The projects under this section attempt to evolve high yielding varieties with better quality and multiple pest resistance through germplasm collection, varietal improvement and screening for pest tolerance. From West Bengal 13 trees have been identified for cluster bearing habit and medium size nuts. During the year 15 clonal accessions were planted in National Cashew Gene Bank which brings the total number of accessions planted so far to 300. The combination H-10 (M37/3 x Tree No.1) continued to perform better than others in progeny trial I with a yield of 6.6 kg/tree year. In progeny trial II, S-34 (Tree No.1 x Tree No.1) gave a yield of 3.03 kg/tree/year. In progeny trial III, the highest mean yield of 6.8 kg/tree/year was recorded in H-20 (BLA-139-1 x M10/4). In the maximization of yield plot, M44/3 continued to yield (3.2kg/tree) higher than M10/4. In nodal culture of seedlings MS media supplemented with 2-ip (2.5mg/l) and NAA (0.1 to 1.0mg/l) was found to enhance the shoot bud proliferation.

Gen. I(176) : Collection, conservation, cataloguing and evaluation of cashew germplasm

(KRM Swamy, KV Nagaraja, MGangadhara Nayak and N. Yadukumar)

The objectives of this project are collection of both indigenous and exotic germplasm, establishment of National Cashew Gene Bank for conserving the available genetic diversity, cataloguing and evaluation of the existing germplasm.

Germplasm collection

A survey was undertaken in Digha and Depal area of Midnapore District of West Bengal during April 1993 in collaboration with Jhargram Centre of All India Coordinated Research Project on Cashew (BCKV). Thirteen trees were marked for their cluster bearing habit and medium nut size during the survey (Table 1).

Scion sticks of 22 germplasm collections and two released varieties were obtained from West Bengal (Midnapore District), Orissa (Puri and Ganjam districts) and Kerala (Cashew Research Station, Madakkathara), and soft wood grafts were prepared. At the time of grafting, the age of the detached scion sticks ranged from 2-7 days. The graft success was over 50 percent in majority of the cases.

The net weight of bulk nuts received from Project Coordinator (Palms) ranged between 5 and 10.5g with a mean of 6.5g. A total of 73 seeds were sown in polythene bags after treating the seeds with benlate

Table 1. Salient features of cashew germplasm collected from Midnapore district of West Bengal during 1993

Name of collection	Age of tree (years)	No. of fruits/panicle	Nut weight (g)
Barbaria - 1	16	08-10	7.0
Barbaria - 2	16	03-04	7.5
Barbaria - 3	16	15-20	4.0
Barbaria - 4	25	02-03	8.0
Deepal - 1	15	03-04	8.0
Deepal - 2	12	01-02	8.5
Deepal - 3	40	07-08	8.0
Deepal - 4	25	03-04	8.0
Deepal - 5	30	01-02	8.0
Hameerpur - 1	25	08-10	8.0
Hameerpur - 2	20	15-20	5.0
Hameerpur - 3	30	15-20	5.0
Hameerpur - 4	20	10-15	6.0

(1%). Of the 73 seeds sown, only 20 germinated (27.4%). These seedlings would be evaluated in the field for identifying dwarf or semidwarf types, if any.

Germplasm conservation

Fifteen clonal accessions (NRC 286-300) were planted (6 soft wood grafts per accession) in the National Cashew Gene Bank with a closer spacing of 6m x 6m (Table 2).

Table 2. Clonal germplasm accessions planted in the National Cashew Gene Bank

Accession No. (NRC)	Name of collection
286	Kothur-1
287	Kothur-6
288	Hadigere-1
289	H. Gollahally-1
290	Dinnahally-1
291	Hebri-1
292	Hebri-2
293	Hebri-3
294	Chickadasarahally-1
295	Chickadasarahally-6
296	Chickadasarahally-8
297	Hogalagere-1a
298	H. Gollahally-1a
299	H. Gollahally-1b
300	M 26/2 (VRI-3)

Of the fifteen accessions, 14 were collected from Kolar district and one (Acc. No. 300) from Regional Research Station, Vridhachalam (Tamil Nadu). Details on the clonal accessions planted so far in National Cashew Gene Bank since 1986 is presented in Table 3.

Germplasm evaluation

1. Trunk girth of cashew accessions

Observations on trunk girth of the accessions at 15 cm from ground level were recorded during January 1994, the details of which are given in Table 4. The trunk girth of cashew accessions planted during different years ranged from less than 10 cm to 70 cm.

2. Nut yield of cashew accessions

The cumulative yield/plant was recorded for the accessions planted from 1986 to 1991. The yield ranged from less than 0.5kg/plant to 8.0kg/plant among accessions planted during different years (Table 5).

3. Studies on yield stabilization

Data on yield stabilization in cashew were recorded in terms of plant height (m), trunk girth (cm), canopy spread (m)-North South and East West, number of leaders/m², number of productive and unproductive laterals/m² in selected cashew accessions during February 1994. Fifteen accessions (5 early season, 5 mid season and 5 late season types, each) were utilized from the accessions planted during 1988, 1989 and 1990 for recording the observations. The mean values for the growth parameters are presented in Table 6.

4. Studies on physiological parameters

Physiological parameters such as net photosynthesis, transpiration, stomatal conductance, intercellular CO₂ concentration and water use efficiency were recorded on 20 cashew accessions with the help of LCA-3 photosynthesis system during February, 1994. Maximum photosynthetic efficiency was recorded in the accession

Table 3. Clonal germplasm accessions planted in the National Cashew Gene Bank during 1986-1993

Source of collection	Number of accessions planted		
	Existing	During '93	Total
Elite and diverse material selected from germplasm (seedlings progeney) at			
Vittal	69	—	69
Shantigodu	75	—	75
Primary collections from			
Karnataka	40	14	54
Andhra Pradesh	26	—	26
Tamil Nadu	08	01	09
Goa	40	—	40
Maharashtra	14	—	14
Orissa	09	—	09
West Bengal	01	—	01
Kerala	03	—	03
Total	285	15	300

NRC 118 ($11.07 \mu \text{ mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$) and minimum in NRC 121 ($5.10 \mu \text{ mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$). The transpiration was the highest in NRC 132 ($17.80 \text{ m mol H}_2\text{O m}^{-2} \text{ s}^{-1}$) and it was the least in NRC 119 ($10.80 \text{ m mol H}_2\text{O m}^{-2} \text{ s}^{-1}$). The maximum stomatal conductance was observed in NRC 126 ($0.58 \text{ mol m}^{-2} \text{ s}^{-1}$) and the minimum in NRC 131 ($0.29 \text{ mol m}^{-2} \text{ s}^{-1}$). The water use efficiency was the highest in NRC 118 ($1.00 \mu \text{ mol CO}_2 / \text{m mol H}_2\text{O/sec}$) and it was the lowest in NRC 121 ($0.41 \mu \text{ mol CO}_2 / \text{m mol H}_2\text{O/sec}$) (Table 7).

5. Biochemical characterization of cashew accessions

Twenty cashew accessions were characterised for leaf phenols and orthodihydroxy phenols. Matured leaves from twenty accessions (3 plants/accession) were analysed for their leaf phenols and

orthodihydroxy phenols. They exhibited variation for phenols and orthodihydroxy phenols (Table 8). In majority of the accessions the leaf phenols ranged from 0.3 to 0.7 mg/g fresh weight and the orthodihydroxy phenols ranged from 0.1 to 0.4 mg/g fresh weight (Table 9).

6. Relationship between cashew apple weight and nut weight

Correlation studies were undertaken during 1994 fruiting season on 23 accessions in the National Cashew Gene Bank to find out the relationship between cashew apple weight and nut weight. Apples with nuts were randomly collected from each accession (10 per accession) and weight of both apples and nuts were recorded. The mean values for apple and nut weight are presented in Table 10. Simple linear

Table 4. Trunk girth of cashew accessions in the Gene Bank

Year of Planting	No. of accessions	Trunk girth group (cm)	Accessions	
			No.	%
1986	56	<40.0	02	3.6
		40.1-50.0	15	26.8
		50.1-60.0	25	44.6
		60.1-70.0	14	25.0
1987	30	<40.0	01	3.3
		40.1-50.0	11	36.7
		50.1-60.0	13	43.3
		60.1-70.0	05	16.7
1988	67	<30.0	05	7.5
		30.1-40.0	23	34.3
		40.1-50.0	34	50.7
		50.1-60.0	05	7.5
1989	60	<30.0	05	8.3
		30.1-40.0	37	61.7
		40.1-50.0	18	30.0
1990	42	<30.0	21	50.0
		30.1-40.0	20	47.6
		40.1-50.0	01	2.4
1991	14	<20.0	06	42.8
		20.1-30.0	08	57.2
1992	16	<10.0	08	50.0
		10.1-20.0	08	50.0
1993	15	<10.0	15	100.0

correlation coefficient (r) was computed by using the mean values. The computed r value (0.852) was found to be significant

at 1 per cent level (table $r=0.526$) indicating positive correlation between apple weight and nut weight.

Table 5. Yield of cashew accessions in the Cashew Gene Bank

Year of planting	No. of accessions	No. of annual harvests	Cumulative yield/plant (kg)	Accessions	
				No.	%
1986	56	6	<2.0	12	21.5
			2.01-4.0	24	42.8
			4.01-6.0	14	25.0
			6.01-8.0	5	8.9
			>8.0	1	1.8
1987	30	5	<1.0	2	6.7
			1.01-2.0	11	36.7
			2.01-3.0	14	46.7
			>3.0	3	10.0
1988	67	3	<1.0	3	4.5
			1.01-2.00	44	65.7
			2.01-3.00	17	25.4
			>3.0	3	4.5
1989	60	1	<0.50	36	60.0
			0.50-1.00	23	38.3
			>1.00	1	1.7
1990	42	1	<0.50	32	76.7
			>0.50	10	23.8
1991	14	1	<0.50	14	100.0

Table 6. Mean growth parameters of selected cashew accessions

Growth parameters	1988 planted			1989 planted			1990 planted		
	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late
Plant height (m)	3.5	3.4	3.9	3.1	2.9	5.8	2.6	2.7	2.9
Trunk girth (cm)	40.0	37.5	43.9	36.7	31.7	29.6	29.8	28.2	30.1
Canopy spread (m ²)	25.0	19.9	21.5	22.3	17.6	14.0	11.1	14.2	14.0
No. of leaders/m ²	5.8	5.8	5.9	5.6	5.9	5.3	5.9	5.9	5.8
No. of productive laterals/m ²	7.3	10.3	5.6	4.6	5.1	2.8	5.3	4.7	5.0
No. of unproductive laterals/m ²	5.3	2.9	9.0	7.1	7.1	7.8	8.9	9.7	7.6

Table 7. Physiological parameters in selected cashew accessions

Accession No. (NRC)	Transpiration (m mol H ₂ O m ⁻² s ⁻¹) (EO)	Stomatal conductance (Mol m ⁻² s ⁻¹) (SC)	Net photosynthesis (μ mol CO ₂ m ⁻² s ⁻¹)	Intercellular CO ₂ concentration (ppm) (CI)	Water use efficiency (μ mol CO ₂ /m mol H ₂ O/sec)
118	11.07	0.39	11.07	241	1.00
119	10.80	0.35	8.95	247	0.82
120	11.41	0.26	9.26	240	0.81
121	12.30	0.26	5.10	246	0.41
122	13.83	0.56	7.16	241	0.52
123	14.20	0.49	6.30	245	0.44
124	15.25	0.54	8.65	225	0.56
125	16.00	0.26	9.03	220	0.58
126	11.70	0.58	9.50	249	0.85
127	13.30	0.52	9.95	245	0.74
128	13.10	0.50	7.20	247	0.54
129	13.80	0.32	6.20	244	0.44
130	16.50	0.44	10.10	215	0.61
131	17.60	0.29	10.40	240	0.59
132	17.80	0.48	9.15	230	0.51
140	16.80	0.53	7.70	216	0.45
141	17.40	0.55	7.90	230	0.45
142	17.50	0.35	7.76	227	0.44
152	16.50	0.48	9.06	220	0.54
153	17.50	0.53	7.70	240	0.44

Table 8. Leaf phenols and orthodihydroxy phenols in selected cashew accessions

Accession No. (NRC)	Name of collection	Phenols (mg/g fr.wt)	Orthodihydroxy phenols (mg/g fr.wt.)
191	VTH 146/4I. H3/1	0.76	0.40
192	VTH 133/4I. CNSLF	0.49	0.25
193	VTH 22/2I. M 54/4	0.36	0.15
194	P.No. 765-Ranpur	0.48	0.21
195	VTH 129/25. T.No. 275	0.46	0.21
196	VTH 125/28. T.No. 39	0.59	0.21
197	P.No. 2424-Lahanga	0.46	0.24
198	P.No. 2576-Lahanga	0.28	0.13
199	P.No. 2098-Lahanga	0.69	0.20
200	P.No. 3310-Saradhapur	0.57	0.23
201	P.No. 3254-Taratua	0.57	0.31
202	Kalibatti-I	0.48	0.21
203	T.No. 1-Hadigere	0.55	0.27
204	T.No. 1-Hogalagere	0.61	0.28
205	T.No. 1-Chickadasarahally	0.43	0.22
206	M 45/4	0.49	0.20
207	K 7/1	0.54	0.25
208	M 26/1	0.39	0.19
209	M 68/1	1.00	0.52
210	M 99/4	1.13	0.57

Table 9. Grouping of accessions for leaf phenols and Orthodihydroxy phenols content

	Range (mg/g fr.wt)	No. of accessions	Accessions (NRC)
Phenols	0.2-0.3	1	198
	0.3-0.5	9	192, 193, 194, 195, 197, 202, 205, 206, 208
	0.5-0.7	7	196, 199, 200, 201, 203, 204, 207
	0.7-0.8	1	191
	1.0-1.2	2	209, 210
OD Phenols	0.1-0.2	3	193, 198, 208
	0.2-0.4	15	191, 192, 194, 195, 196, 197, 199, 200, 201, 202, 203, 204, 205, 206, 207.
	0.5-0.6	2	209, 210

Table 10. Correlation between apple and nut weight in cashew

Sl. No.	Accession No. (NRC)	Mean wt/apple (g)	Mean wt/nut (g)	Square of deviates		Product of deviates xy
				x ²	y ²	
1	40	15.3	3.7	21.25.2	14.4	175.2
2	42	50.5	6.2	118.8	1.7	14.2
3	46	27.1	3.8	1176.5	13.7	126.9
4	47	109.5	7.8	2313.6	0.1	14.4
5	92	99.0	10.2	1413.7	7.3	101.5
6	99	31.9	8.5	870.2	1.0	29.5
7	103	87.7	10.3	691.7	7.8	73.6
8	106	40.1	5.7	453.7	3.2	38.3
9	107	99.4	12.3	1444.0	23.0	182.4
10	110	52.9	6.5	72.2	1.0	8.5
11	112	114.6	13.2	2830.2	32.5	303.2
12	113	46.9	7.0	210.2	0.3	7.3
13	117	52.2	10.0	84.6	6.3	23.0
14	120	133.5	11.5	5198.4	16.0	288.4
15	122	33.1	5.8	800.9	2.9	48.1
16	125	15.8	3.5	2079.4	16.0	182.4
17	136	72.0	7.5	112.4	0.0	10.6
18	140	108.0	8.9	2171.6	2.0	65.2
19	142	36.9	5.3	600.2	4.8	53.9
20	147	62.7	8.2	1.7	0.5	0.9
21	148	24.4	4.6	1369.0	8.4	107.3
22	208	34.0	4.7	750.8	7.8	76.7
23	240	65.2	7.9	14.4	0.2	1.5
Total		1412.7	173.1	26903.4	170.9	1828.0
Mean		61.4	7.5		r = 0.852**	

II : Varietal improvement of cashew

(PM Kumaran, Thimmappaiah and N Yadukumar)

This projects envisages improvement of cashew in terms of yield and other desirable characters such as high shelling percentage, resistance/tolerance to tea mosquito and better kernel quality. The objectives of the project are contemplated to be achieved through hybridization, varietal evaluation and selection.

Hybridization and Selection

A total of 72 hybrids and 13 selfed lines are under evaluation in six set of experiments at CPCRI, Regional Station, Vittal (1984 planting) and NRCC., Kemminje, Puttur (1987, 1991, 1992 and 1993 planting). Another 51 elite lines are being evaluated in six experiments (5 experiments at Kemminje, Puttur, and one experiment at Shantigodu - 1986, 1988, 1990 and 1991 planting) for economic characters like yield, shelling percentage, nut size, kernel weight and size of apple. Besides these, interspecific hybrid *Anacardium occidentale* (V5) x *A. pumilum* and its reciprocal and also interspecific hybrid *A. orthonianum* x *A. occidentale* (V5) and its reciprocal, are maintained at Shantigodu.

Trial I

Under this trail, a total of 18 entries (12 combinations and 6 selfs) along with control (M 44/3) planted in 1984 at CPCRI, Regional Station, Vittal, were evaluated in three replications 6 plants/replication in RBD. The performance of cross combinations and selfed lines is given in Table-11.

The highest cumulative yield of 23.23 kg/tree was recorded in H 10 (M 37/3 x T.No. 1) followed by 21.36 kg/tree in H 16 (1/3 Ceylon x A 18/4). These two combinations maintained their superiority from the rest. The cumulative yield recorded in the case of these two hybrids was 158 percent and 138 percent over the control (M44/3). A similar trend was noticed when the yield data of the last two years (1991 and 1992) was analysed. A total of eight cross combinations and two selfs gave a cumulative yield of more than 9 kg/tree/year. In general, selfed lines were relatively poorer in nut yield as compared to the hybrids.

Progeny Trial II

Seven selfed lines planted in 1984 at CPCRI., Regional Station, Vittal were evaluated for yield and other morphological characters. The performance of these selfed lines is presented in Table-12.

The Highest cumulative yield of 20.03 kg/tree for the period 1986-92 was recorded in S 34 (T.No. 1) followed by S-16 (M 16/1) with 15.72 kg/tree. The same trend was observed for cumulative yield for two years (1991 and 1992). The yield obtained in S34 was (3.02 kg/tree/year) double the yield of M 44/3 (1.51 kg/tree/year).

Progeny Trial III

A total of 15 cross combinations and a control (M 44/3) planted in 1984 at CPCRI, Regional Station, were evaluated in RBD

Table 11 Performance of cross combinations/selfed lines for yield under Progeny Trial I

H. No./ S.No.	Cross combination/selfed line	Cumulative yield (1986-92) (kg/tree)	Cumulative yield (1991 & 1992) (kg/tree)
H-1 (S-1)	M 44/3 x M 44/3	19.30	10.04
H-2	13/12 Sanyasi x M 44/3	18.34	9.45
H-3	A 18/4 x 7/10 Tetagunta	16.98	9.83
H-4 (S-4)	13/12 Sanyasi self	11.89	5.43
H-5	BLA-139-1 x T.No. 1	13.72	7.47
H-6	BLA-139-1 x 13/5 Kodur	17.28	10.49
H-7	M 10/4 x WBDC-V	14.94	7.89
H-8 (S-8)	M 37/3 x M 37/3	17.72	9.30
H-9	M 37/3 x A 18/4	16.25	9.02
H-10	M 37/3 x T.No. 1	23.23	13.39
H-11 (S-11)	WBDC-V x WBDC-V	8.56	5.42
H-12 (S-12)	A 18/4 x A 18/4	9.84	5.96
H-13	A 18/4 x 13/5 Kodur	14.10	7.73
H-14	1/3 Ceylon x 13/5 Kodur	18.15	9.12
H-15 (S-15)	1/3 Ceylon x 1/3 Ceylon	13.61	6.41
H-16	1/3 Ceylon x A 18/4	21.36	11.49
H-17	M 37/3 x 13/5 Kodur	11.80	5.81
H-18	1/3 Ceylon x Mys. Kotekar	20.09	11.23
Control	M 44/3 (OP)	9.00	4.59
CD		6.28	4.334

Table 12. Performance of selfed lines for yield under Progeny Trial II.

Self No.	Selfed lines	Cumulative yield (1986-92) (kg/tree)	Cumulative yield (1991 & 1992) (kg/tree)
S-20	M 37/3 (VTH 20) x M 37/3 (VTH20)	9.72	2.89
S-11	M 10/4 x M 10/4	13.32	3.74
S-16	M 16/3 x M 16/3	15.72	5.63
S-120	1/3 Ceylon x 1/3 Ceylon	9.29	2.70
S-127	T.No. 270xT.No. 270	10.57	2.87
S-34	T.No. 1 x T.No. 1	20.03	6.06
S-12	M 44/3 x M 44/3	10.51	3.03

Table 13. Performance of cross combinations for yield under Progeny Trial III.

H.No.	Cross combination	Cumulative yield (1986-92) (kg/tree)	Cumulative yield (1991 & 1992) (kg/tree)
H-19	A 18/4 x BLA-139-1	11.37	4.55
H-20	BLA-139-1 x M 10/4	22.35	13.62
H-21	A 18/4 x M 10/4	10.12	5.30
H-22	A 18/4 x Vetore-56	9.87	4.91
H-23	7/10 Tetagunta x A 18/4	7.84	4.89
H-24	BLA-139-1 x A 18/4	11.12	6.43
H-25	7/10 Tetagunta x BLA-139-1	11.56	7.69
H-26	M 37/3 x 7/10 Tetagunta	8.38	4.78
H-27	M 44/3 x 9/8 EPM	14.07	8.53
H-28	M 16/3 x 13/5 Kodur	12.56	8.76
H-29	T.No. 1 x 7/10 Tetagunta	5.53	2.48
H-30	WBDC-V x M 10/4	9.53	6.49
H-31	Mys. Kotekar x 13/5 Kodur	6.81	4.07
H-32	T.No. 1 x M 10/4	11.11	7.01
H-33	WBDC-V x 13/5 Kodur	4.63	2.98
Control	M 44/3	3.22	1.89

(two replications 4 plants/plot). The performance of these combinations for cumulative yield is given in Table-13.

H-20 (BLA-139-1 x M 10/4) was identified as the best combination with respect to nut yield. The yield recorded in this combination was six times more than that of control (M44/3). In this cross combination, 22.35 kg/tree was recorded as cumulative yield (1986-92) and 13.62 kg/tree as the cumulative yield of 1991 and 1992. H 27 (M 44/3 x 9/8 EPM) was found to be the next best combination for cumulative yield (1986-92) with an yield of 14.07 kg/tree closely followed by H-28 (M 16/1 x 13/5 Kodur) with a yield of 12.56 kg/tree. For cumulative yield of 1991 and 1992, H-

28 gave the second maximum yield of 8.76 kg/tree closely followed by H-27 (8.53 kg/tree).

As per the decision of Sixth Research Council, the high yielding trees from progeny trials of CPCRI Regional Station, Vittal, were identified, clonally multiplied and planted in an evaluation trial at NRCC during the year under report. Grafts from five selected trees from Vittal trials and two trees from NRCC, Puttur, were made and planted along with 3 NRCC selections and a control in a replicated trial in 1992-93. During the year under report, soft wood grafts from another set of seven selected trees from CPCRI Regional Station, Vittal, have been made for planting in 1994 at Kemminje.

Hybridization for improvement of nut size in released varieties

Hybridization programme was continued to improve the nut size in the released varieties. An experiment was initiated to improve the nut size of released varieties (M 44/3, BLA-139-1 and V-5). They were crossed with bold nut size varieties VTH-711/4 (Brazilian) and VTH 40/1 (Selection-2). The six hybrids so generated were planted in 1991, 1992 and 1993. Hybrid nuts produced by crossing released varieties with bold nut types were harvested. A total of 291 hybrid nuts were produced in nine cross combinations which comprised of six crosses in the above programme and three interspecific crosses (V-5 x *A. pumilum*, interspecific hybrid x V-5 and interspecific hybrid x 40/1). These hybrid seeds were sown in nursery and 259 hybrid seedlings could be raised. A total of 259 hybrid cashew

plants along with 11 plants of 3 parental lines (270 plants) were planted in the field. The planting was carried out at a closer spacing of 6m x 6m. The details of cross combinations and the number of seedlings planted are given in Table 14.

Four trees were identified for the improved nut weight, shelling percentage and earliness. The details of trees, mean nut weight including range, kernel weight, and shelling percentage are presented in Table 15. The highest mean nut weight (9.4g) was recorded in T.No. 1223 (BLA-139-1 x 40/1). The highest kernel weight (2.6 g) was observed in T.No. 1250 and the increase in nut weight over its female parent was 72.5 percent. The highest shelling percentage (31.8) was recorded in T.No. 1306 with 87 per cent increase of nut weight over its mother parent.

Table 14. Details of cross combinations planted for improvement of nut size in released varieties

Hybrid No.	Cross combination/genotype	No. of seedlings planted
1	VRI-2 (M 44/3) x VTH 40/1	11
2	BLA-139-1 x VTH 711/4	10
3	V-5 x VTH 711/4	35
4	BLA-139-1 x VTH 40/1	47
5	VRI-2 (M 44/3) x VTH 711/4	1
6	V-5 x VTH 40/1	137
7	V-5 x <i>A. pumilum</i>	6
8	Interspecific hybrid x V-5	6
9	Interspecific hybrid x 40/1 (Sel. 2)	6
10	711/6 (OP)	3
11	V-5 (OP)	4
12	BLA-139-1 (OP)	4
	Total	270

Table 15. Details of selected F1 progenies identified under the programme on Improvement of nut size in released varieties

T.No.	Parentage	Nut weight		Mean kernel wt. (g)	Shelling %	% increase of nut weight over mother parent
		Range (g)	Mean nut weight (g)			
T. 1223	BLA-139-1 x 40/1	9.0-9.8	9.4	2.5	28.6	56.6
T. 1205	M 44/3 x 40/1	7.9-10.3	8.4	2.1	25.0	64.7
T. 1306	V-5 x 711/4	6.5-9.4	7.5	2.4	31.8	87.0
T. 1250	M 44/3 x 40/1	7.1-10.8	8.8	2.6	29.0	72.5

Table 16. Details of hybrids/selfed lines identified for clonal evaluation

Tree No.	Cross combination/selfed lines	Nut wt. (G)	Kernel wt. (g)	Shelling %	Cumulative yield (Kg)
H 3/11	A 18/4 x 7/10 Tetagunta	7.9	2.3	29.7	19.8
S 15/1	1/3 ceylon self	7.9	2.2	28.3	12.5
H 14/9	1/3 ceylon x 13/5 Kodur	7.0	2.0	28.0	17.4
H 16/18	BLA-139-1 x 13/5 Kodur	6.9	2.2	30.9	16.5
H 24/4	BLA-139-1 x A 18/4	7.1	2.2	30.0	15.6
H 10/7	M 37/3 x T.No. 1	6.0	2.0	33.0	20.5
S 1618	M 16/1 self	6.9	2.2	30.4	17.1

Evaluation of promising hybrids and selections of NRCC

A replicated trial consisting of four hybrids from Vittal, two hybrids from Puttur, one selfed line from Vittal, three selections of NRCC and a control (VRI-2) was laid out in 1992-93. Further, five individual hybrids and two selfed lines were identified from Vittal, for the clonal evaluation. The selections made were based on the individual tree yield and other yield attributes like nut weight (8-10 Kg/tree) kernel weight (>2g), shelling percentage (25-28%) and cumulative yield. The details of the cross-combinations and their economic characters are given in Table 16. A total of

50 scions each from the seven lines have been collected and soft wood grafts have been made for planting in 1994.

A comparative study of grafts vs. clonal seedlings

Five lines were selected for this study to compare the grafts and clonal seedlings. The lines selected were 10/3, 11/4, 12/2, 59/2 and 150/4. A seedling (M 10/4) was identified with improved nut size and kernel weight. The nut weight varied from 10.3g to 14.5 g with a mean of 12.9g. The plant is under observation for nut yield and other characters.

Hybridization for transfer of cluster bearing habit from V-2

The crossing of BLA-139-1 and V-2 was undertaken in order to transfer cluster bearing habit of V-2 to BLA-139-1 variety. Nine crossed nuts have been obtained. They have been sown and five seedlings could be raised. These five seedlings will be planted in the field in 1994.

Evaluation of recommended varieties

Clonal materials of 12 recommended varieties planted in 1986 were evaluated for yield and other characteristics in RBD with three replications and six plants per plot. In flowering, H 2/11 was the earliest with fruiting as early as in October to November. The late varieties were Ullal-1 and T.No. 56. Regarding yield, T.No. 56 of Bapatla recorded the highest (0.9 kg/tree) followed by M 10/4 (0.8 kg) and Ullal-1 (0.7 kg/tree). In cumulative mean yield, however, M 44/3 was superior with 0.7 kg/tree/year, than others.

Evaluation of hybrids planted during 1987

Hybrid seedlings (145) from 33 cross combinations planted in 1987 under closer spacing (6m x 6m) were evaluated at Puttur. In yield, the hybrid combination VTH-52 x VTH-50 gave the highest yield during the year (1.68 kg/tree) followed by control M 44/3 (1.60 kg). In cumulative mean yield, VTH-12 x VTH-11 was the highest yielder (1.0 kg/tree/year). During the year, Tree No. 16, 18, 4, 23, and 14 were identified as having high yield potential and each gave a yield of over 2.5 kg/tree.

Maximisation of yield plot

Yield performance of two recommended varieties M 10/4 and M 44/3 planted in the year 1986 with plot size of 0.6 ha was monitored during the year. A total of 229 kg/plot was harvested (382 kg/ha) with a mean yield of 2.2 kg/tree and the cumulative mean yield being 1.1 kg/tree/year. Among the two, M 44/3 gave higher

Table 17. Physiological parameters recorded during flushing season in 12 recommended varieties

Variety	PAR	Temperature (°C)	Transpiration (μ mol $m^{-2}s^{-1}$)	Photosynthesis (μ mol $CO_2 m^{-2}s^{-1}$)	Intercellular CO_2 (ppm)
BLA-39-4		38.8	7.4	7.4	457
H-2/12		38.1	7.4	7.0	362
H 31/3		38.1	6.9	7.2	380
M 44/3	1459	37.3	5.9	4.8	273
EPM 9/8		36.3	6.7	7.5	336
BLA-139-1		35.3	6.8	7.4	458
Ullal-1		35.5	7.0	8.1	481
H 2/11		35.2	5.6	7.4	449
M 10/4		36.2	7.0	8.6	440
T.No. 1		35.6	7.7	5.4	478
H-3-17		34.4	5.9	7.8	415
T.No. 56		31.6	8.0	7.0	474

Table 18. Physiological parameters recorded during fruiting season of 12 recommended varieties

Variety	PAR	Temperature (°C)	Transpiration (μ mol m ² s ⁻¹)	Photosynthesis (μ mol CO ₂ m ² s ⁻¹)	Intercellular CO ₂ (ppm)
BLA-39-4		31.2	6.0	7.5	330
H-2/12		31.9	6.7	8.9	304
H 31/3		32.4	5.0	6.5	290
M 44/3	1016	33.9	6.1	9.3	273
EPM 9/8		34.7	6.1	7.4	282
BLA-139-1		34.8	8.2	12.6	280
Ullal-1		34.4	7.7	11.4	277
H 2/11		34.9	7.6	11.8	270
M 10/4		35.3	6.9	9.4	262
T.No. 1		31.2	9.0	9.5	293
H-3-17		33.5	9.9	12.1	258
T.No. 56		36.4	11.4	12.5	325

yield with a mean of 3.2 kg/tree. The cost of cultivation for the seventh year (1992-93) was Rs. 2745/plot (Rs. 4575/ha).

Physiological studies on recommended varieties

The photosynthetic efficiency of 12 recommended varieties along with other physiological characters such as leaf temperature, intercellular CO₂ and PAR were studied in selected plants from three replications planted in 1986, during the flushing and fruiting seasons (2 plants/variety/repl = 72 plants/12 varieties/3 reps). The physiological parameters for different varieties during flushing season are given in Table 17.

The photosynthetic efficiency varied

from 4.8 to 8.6 and the highest was recorded in M 10/4. The next highest value of 8.1 was recorded in Ullal-1. The rate of transpiration varied from 5.6 to 8.0. The average PAR (photosynthetically active radiation) value above the crop canopy at the time of taking observation was 14.59 mol m² s⁻¹.

Similarly the observations on physiological parameters were recorded during the fruiting season and the results are presented in Table 18. Maximum photosynthetic efficiency was recorded in BLA-139-1 (12.6) and in T.No. 56 (12.5). The rate of transpiration varied from 5.0 to 11.4. The average PAR value above the crop canopy at the time of taking observation was 1016 mol m²s⁻¹.

Gen. III : Tissue culture studies in cashew for micropropagation and somaclonal variation

(Thimmappaiah and KV Nagaraja)

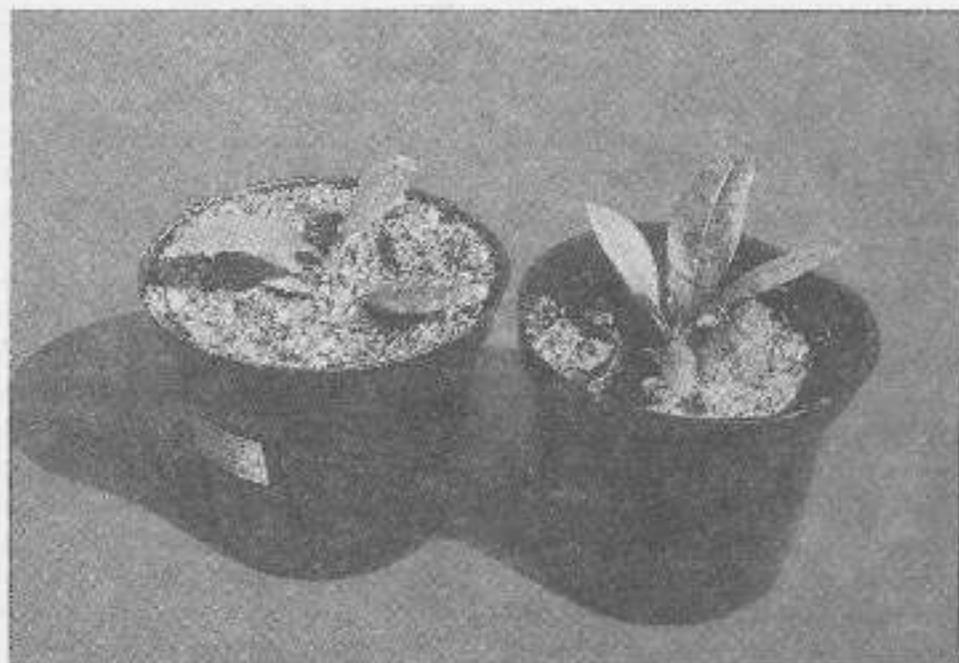
The project was initiated during 1989-90 with an objective of standardizing micropropagation technique in cashew and to induce and exploit somaclonal variation for breeding purpose.

Micropropagation

Nodal culture of young cashew seedlings was made on MS media supplemented with 2 and 5 mg/l of different cytokinins (BAP, 2ip, Kinetin and Zeatin).

1 of 2 ip, however, the single shoot production was the highest (46%). Supplementing MS media with 2ip (2.5 mg/l) and NAA (0.1-1.0 mg/l) was found to enhance shoot bud proliferation (4-20%). In medium with 2ip (5mg) and NAA (0.1mg), a maximum of 20 per cent of the explants showed 3-4 shoot buds.

Double phase medium (solid medium overlaid with liquid medium) was also



Potted micro propagated plants.

The percentage of bud opening and shoot growth increased with increase in the concentration of cytokinin from 2mg to 5mg/l. In media supplemented with 5mg/

found to enhance the axillary shoot bud proliferation. Solid medium with either MS or Leiven's multiplication medium overlaid with 5-8 mg/l of BA and GA₃ solution (0.5-

1.0 mg/l) showed shoot bud proliferation in 65 to 77 per cent of the cultures.

Shoot bud elongation on the induction medium was confined to one bud only in solid medium. In liquid medium of 2 ip (2mg) and NAA (1mg/l) under shaker (100 rpm) the shoot elongation could be enhanced to 31 per cent.

For rooting of single elongated shoots half strength MS supplemented with IAA (1-8 mg), NAA (2-4 mg) and IBA (2-4 mg) was tried. The rooting was limited to only 10 to 20 per cent of the shoots in IAA and NAA media. The rooted microshoots were weaned and acclimatised in pots containing 1:1 mixture of soilrite and sand.

Nodal culture of mature tree were also made on WPM and half strength MS supplemented with BA (1mg/l). Establishment was poor due to high rate of contamination (>90%) and tissue necrosis. Soaking explants in bavistin (0.5% w/v) for 4 hours and incorporation of either neomycin sulphate (1000 ppm) or neomycin and gentamycin in combination (500 ppm each) was found to reduce fungal and bacterial contamination significantly (0-16%). Among the different antioxidants tried, PVP-40 and activated charcoal (0.4%) showed negligible exudation and maximum retention of green shoots (40%).

Phenols and orthohydroxy phenols from different explants (leaf, shoot tip, nodes) were analysed from both high phenol (NRC 189) and low phenol types (NRC 132). Among three explants, the leaf segment had the highest phenol content followed by nodal cutting and shoot tip.

Callus culture

Internode segments from young cashew seedlings and leaf segments excised from seedlings raised *in vitro* were cultured on MS modified medium supplemented with 2,4-D and NAA (1,2,4,8 mg/l) each and in combination with BAP (0.0, 0.1, 0.5, 1.0, and 2.0 mg/l). Callus induction from internode segments was maximum (87.5%) in media containing 2,4-D and BAP in equal proportion (1:1). In NAA combination media, the callus induction was negligible. However, adventitious root formation was seen. Leaf segments showed callus induction in all the explants in media containing 2,4-D (4 mg/l) with or without BA. In NAA media, the callus formation was scanty and took place in 16-75 percent of explants and adventitious root formation was seen at higher dose (4 and 8 mg/l of NAA). Callus in leaf was white in colour and confined more on the veins and midrib. Callus was also induced in shoot and leaf sections of high phenol type and low phenol types on MS medium supplemented with 2,4-D (1-8 mg/l). In shoot, the callus induction varied from 37.5 to 66.7 per cent and in leaf it varied from 16.6 to 54.2 per cent.

Nucellus culture

Nucellus tissue excised from immature nuts of M 44/3 showed callus formation in 20 per cent of the explants on MS modified media supplemented with 2,4-D (0.5 mg/l). Multiplication of the callus was undertaken in media containing both 2,4-D and BAP (1-2 mg/l). The callus grew profusely and became friable on NAA/IAA (1mg/l) media supplemented with Zeatin (1 mg/l). Subculturing of this calli on media containing 2ip (0.5 mg) and coconut water

(15%) resulted in white globular embryonic structures. These embryogenic structures on either MS basal medium or on ABA (0.1-0.5 mg/l) media showed germination with prominent root formation and poor shoot differentiation.

Cotyledon culture

Immature cotyledonary segments excised from 6-7 week old nuts were cultured on five media formulations of MS containing 2,4-D, BA (1mg/each), NAA (5mg/l), coconut water (10%) and IAA in different combi-

nations. Embryogenesis was observed in 5 to 21 percent of the explants 5 to 6 weeks after incubation in all the combinations except in media with IAA and BA. Direct embryogenesis without the intervening callus was observed in media devoid of 2,4-D. Maturity and germination of somatic embryos were observed on both hormone free basal medium and media containing ABA (0.1-0.5mg/l). Taproot development was prominent and shoot development was suppressed during germination.



Somatic embryo formation from immature cotyledonary segments

AGROTECHNIQUES

Research projects under this section attempt to increase the production of cashew by developing suitable orchard management techniques. The mean yield increased with increased application of N from 250g to 750g/tree/year. A net profit of Rs. 15,692 was realised from the plot receiving the highest dose of N (750g/tree/year) as compared to the lowest dose (250g/tree/year). Irrigated plants showed increased growth parameters compared to control. The cumulative yield in the plot intercropped with pineapple continued to be higher (33.07kg/plot) than that of other plots. Soil samples from the plots with cashew and covercrops, and cashew with pineapple had maximum N and P contents respectively. The lowest yield was realised from the plots intercropped with acacia even after its removal. Maximum net profit was realised from plot intercropped with casuarina (Rs. 38,204/ha). Maintaining plant density of 278 trees/ha (6mx6m) gave highest yield (475 kg/ha). The highest cumulative yield (11 years after planting) of 4.238 t/ha was, however, noticed in the case of 4mx4m spacing (625 trees/ha). Soft wood grafting is successful with decapitated green scions with flower panicles and matured scions with damaged terminal portion as well as spouted terminals. The height and internodal length of 6 month old seedling were different between dwarf and normal types.

Agr. I (b) : Response of high yielding varieties of cashew to different levels of Nitrogen

(N Yadukumar and MG Nayak)

This experiment aims at evaluating the eight promising selections identified from germplasm collection at CPCRI, Regional Station, Vittal, for various characters. The experiment was planted at Vittal during 1983 with the varieties WBDC-V, M 6/1, M 10/4, M 44/3, T.No. 1, A 18/4, 13/5 Kodur and BLA-139-1 as sub-plot treatments. The two other factors are: (1) three levels of nitrogen, viz., 250, 500 and 750 g/plant/year and (2) two types of planting materials, viz., seedlings and grafts. The trial was laid out in a split plot design with two replications.

Yield

The mean yield of nuts/tree increased with increased application of N from 250 g to 750 g/tree/year. The difference among treatments, however, was non-significant.

Among the grafts, the highest yield was in M 6/1 followed by M 44/3 and A 18/4. In the case of seedlings the highest yield was recorded in A 18/4 followed by M 6/1 and BLA-139-1 (Table 19).

Benefit/cost analysis

Cumulative cost of cultivation and net profit realised for the first ten years after planting at three levels of N applications are presented in Table 20. Increase in net profit by Rs. 15,692/ha was observed in plot receiving the highest dose of N fertilizer (750 g/tree) as compared to the lowest dose of N fertilizer (250 g/tree). The corresponding increase in the profit in the case of fertilizer application of 500 g N/tree as compared to the lowest dose of fertilizer application (250 g N/tree) was only very marginal (Rs. 4044/ha). The increase in

Table 19. Nut yield (kg/ha) as affected by three levels of N (10 years after planting)

Varieties	Treatment			Mean	Seedling	Grafts
	N 250	N 500	N 750			
WBDC-V	2.32	2.57	3.49	2.79	2.86	2.72
M 6/1	3.72	3.42	4.71	3.95	3.56	4.33
M 10/4	2.67	3.22	3.27	3.05	3.12	2.48
M 44/3	2.76	2.52	4.23	3.17	2.76	3.59
A 18/4	2.73	3.65	4.20	3.53	3.89	3.15
T.No. 1	1.69	2.20	3.22	2.37	2.12	2.61
Kodur 13/5	2.01	2.66	3.17	2.61	2.59	2.64
BLA-139-1	2.76	2.95	3.09	2.93	3.20	2.67
Mean	2.58	2.90	3.67	3.05	3.01	3.09

CD for Main plot (N levels x planting materials) 1.20 NS

CD for sub plot (varieties) 0.82

Table 20. Benefit/cost analysis for the first ten years after planting

N fertilizer levels (g/tree/ha)	Cumulative cost of cultivation (Rs.)	Nut yield (kg/ha)	Value (Rs.)	Net profit (Rs.)
250	36,989	2271	52,450	15,461
500	39,571	2555	59,076	19,505
750	42,219	3175	73,372	31,153

cost of cultivation was only Rs. 5230/ha due to increase in fertilizer application from 250g N to 750g N/tree.

The calculation presented in Table-20 is based upon the rates for cashewnuts as per the prevailing market price for the corresponding years. The rates for cashewnuts (raw) for the corresponding years were as under:

1986 to 1988 (3 years to

1989	5 years after planting)	Rs. 14.00/kg
1990	(6 years after planting)	Rs. 20.00/kg
1991	(7 years after planting)	Rs. 25.00/kg
1992 & 1883	(8 years after planting)	Rs. 30.00/kg
	(9 and 10 years after planting)	Rs. 22.00/kg

Agr. III (a) : Economic feasibility of drip irrigation and graded doses of NPK on the productivity of cashew

(N Yadukumar)

This experiment was laid out in 1989 in split plot design with four replications. The main plot treatments are drip irrigation at the rate of 20, 40, 60 and 80 litres/tree once in four days during dry months with a control plot. The sub-plot treatments are (1) No fertilizer; (2) 250 g N, 62.5g P₂O₅ and 62.5 g K₂O/tree; (3) 500g N, 125g each of P₂O₅ and K₂O/tree and (4) 750g N, 187.5 g each of P₂O₅ and K₂O/tree respectively. Here, apart from working out the irrigation requirements, fertilizer use efficiency will also be studied.

Growth characters

Observations on growth showed increased girth (Table 21), height (Table 22) spread (Table 23) and ground coverage (Table 24) in the case of irrigated plants as compared to the control. The differences among the irrigation treatments (I₂ to I₅) were not significant though increasing trend was observed except in I₄ treatment in all the above growth characters.

Table 21. Girth (cm) as affected by irrigation and fertilizer treatments

Irrigation treatment	Fertilizer treatment				Mean
	M ₁	M ₂	M ₃	M ₄	
I ₁	37.12	39.32	37.37	37.55	37.84
I ₂	40.47	39.57	42.40	41.15	40.89
I ₃	42.22	38.97	41.15	40.47	40.70
I ₄	42.62	42.25	40.65	41.25	41.68
I ₅	42.20	41.72	45.15	44.30	43.34
Mean	40.92	40.36	40.74	40.94	

CD for Irrigation - (MP) - 2.87

CD for Fertilizers - (SP) - NS

Table 22. Height (cm) as affected by irrigation and fertilizer treatments

Irrigation treatment	Fertilizer treatment				Mean
	M ₁	M ₂	M ₃	M ₄	
I ₁	367	408	378	381	383
I ₂	374	407	427	408	404
I ₃	363	379	405	434	395
I ₄	360	400	392	398	387
I ₅	404	383	409	413	402
Mean	374	395	402	407	

CD for Irrigation - NS

CD for Fertilizers - 19.50

Table 23. Spread (NS and EW) (cm) as affected by irrigation and fertilizer treatments

Irrigation treatment	Fertilizer treatment				Mean
	M ₁	M ₂	M ₃	M ₄	
I ₁	517.6	496.2	422.0	497.1	483.2
I ₂	543.1	531.4	571.2	541.1	546.7
I ₃	582.6	553.1	538.2	585.5	564.8
I ₄	564.7	559.2	556.4	529.6	552.5
I ₅	573.5	573.4	577.0	607.2	582.8
Mean	556.3	542.7	532.9	552.1	546.0

CD for Irrigation - (MP) - 45.85

CD for Fertilizers - (SP) - NS

Table 24. Ground coverage (m²) by individual tree as affected by irrigation and fertilizer treatments

Irrigation treatment	Fertilizer treatment				Mean
	M ₁	M ₂	M ₃	M ₄	
I ₁	22.83	19.33	13.98	19.39	18.88
I ₂	23.15	22.16	25.35	22.98	23.41
I ₃	26.65	24.02	22.74	26.91	25.08
I ₄	25.04	24.55	24.30	22.02	23.98
I ₅	25.82	25.81	26.13	28.95	26.67
Mean	24.70	23.17	22.50	24.05	23.60

Among the NPK fertilizer treatments including control, the differences were non-significant. During the period, moisture depletion studies were also initiated in the case of daily irrigation and once in four days and the same are in progress.

Yield

Irrigation increased the nut yield marginally as compared to control (Table-25). Among different irrigation treatments (I₂ to I₅) the yield in the case of I₄ and I₅ (0.94 and 0.97 kg/tree) was the highest compared to I₂ and I₃ (0.81 and 0.8 kg/tree).

Table 25. Initial nut yield (kg/tree) of individual tree as affected by different irrigation and fertilizer treatments (4 years after planting)

Irrigation treatment	Fertilizer treatment				Mean
	M ₁	M ₂	M ₃	M ₄	
I ₁ Contol	0.72	0.71	0.73	0.64	0.70
I ₂ 20 lit/tree	0.66	0.73	0.85	0.99	0.81
I ₃ 40 lit/tree	0.83	0.72	0.77	0.89	0.80
I ₄ 60 lit/tree	0.79	0.89	0.98	1.11	0.94
I ₅ 80 lit/tree	0.90	1.03	0.85	1.12	0.97
Mean	0.78	0.82	0.84	0.95	

M₁ = No fertilizer

M₂ = 250g N, 67.5g P₂O₅ and 67.5g K₂O/tree/year

M₃ = 500g N, 125 g P₂O₅ and 125 g K₂O/tree/year

M₄ = 750g N, 187.5g P₂O₅ and 187.5g K₂O/tree/year

Agr. IV : Cashew based cropping system : Inter and mixed cropping with cashew

(N Yadukumar and B. Nagaraja)

An experiment was laid out in 1987 with an objective of finding out a suitable crop that could be profitably grown as intercrop in the interspaces of cashew rows during the initial years of orchard life.

Growing tree species as intercrops upto five years after planting, affected the main crop (cashew) thereby reducing the yield significantly. Hence it was decided to remove all the tree species (casuarina, acacia and subabul) expecting that the crop would recover after the removal of tree species.

Observations were recorded one year after removal of intercrops on photosynthesis and other physiological parameters in cashew before and after the removal of the tree species to see the effect on net photosynthesis. There was a marked increase in PAR values (Table 26) and net photosynthesis (PAR-1224, P_N 7.2, 8.4 and 8.6) in all the plots one year after removal as compared to the values before the removal of tree species (PAR 97, 300 and 558, P_N 2.7, 4.6 and 6.1).

Yield

The yield data during the initial years (5 and 6 years after planting) before and after removal of intercrops are presented in Table 27.

The yield realised from the plot intercropped with pineapple continued to be significantly higher than that of other

plots. The lowest yield was realised from the plot intercropped with acacia even after the removal of the tree species (acacia). In general, an increase in yield was observed over the previous year (before the removal of tree species) in the plots intercropped with tree species.

Soil analysis for nutrient content

Soil analysis for NPK and Ca content showed that N content in soil was maximum in the cashew+covercrop plot and minimum in the control plot (cashew alone). Phosphorus content was the maximum (37.7 kg/ha) in the cashew + pineapple plot and minimum in control plot.

The potassium content was comparatively higher in plots where cashew was grown with cover crop and casuarina. With regard to Ca content, maximum concentration (183 ppm) was observed in cashew + subabul plot and minimum in the plot where acacia is grown as intercrop (Table 28).

Microflora population in the plots

By serial dilution and planting, bacteria, fungi, nitrogen fixing bacteria, phosphate solubilising bacteria, and actinomycetes were enumerated in the soil samples collected from different plots under cashew based cropping system. Preliminary results indicated an increase in population of actinomycetes and decreased counts of fungi, nitrogen fixing and phosphate solubilising bacteria in soils collected

Table 26. Photosynthesis and other related parameters of cashew under different cropping systems before and after removal of tree species (acacia, subabul and casuarina)

	PAR ($\mu\text{mol m}^{-2}\text{s}^{-1}$)		PN ($\mu\text{mol CO}_2 \text{ m}^{-2}\text{s}^{-1}$)		GS ($\text{mol m}^{-2}\text{s}^{-1}$)		G (ppm)		E ($\text{m mol H}_2\text{O m}^{-2}\text{s}^{-1}$)		WUE ($\mu\text{mol CO}_2 \text{ m mol H}_2\text{O}$)	
	Before removal of tree spp. (1992)	After removal of tree spp. (1993)	Before removal of tree spp. (1992)	After removal of tree spp. (1993)	Before removal of tree spp. (1992)	After removal of tree spp. (1993)	Before removal of tree spp. (1992)	After removal of tree spp. (1993)	Before removal of tree spp. (1992)	After removal of tree spp. (1993)	Before removal of tree spp. (1992)	After removal of tree spp. (1993)
Cropping systems prevailing in 1992												
Cashew monocrop	1229	1224	9.6	10.2	0.89	0.92	256	272	6.65	8.8	1.44	1.66
Cashew+ acacia	97	1224	2.7	7.2	0.72	0.79	236	258	8.02	8.2	0.37	0.87
Cashew+ casuarina	330	1224	4.6	8.4	0.80	0.85	204	254	7.24	8.4	0.63	1.00
Cashew+ subabul	558	1224	6.1	8.6	0.79	0.90	214	280	7.05	7.8	0.86	1.10

from plots where casuarina and acacia are grown as intercrops.

Benefit/cost analysis

Based upon the cost of cultivation and total income realised from each treatment plot of 384 square metres the benefit/cost analysis was done by extrapolating the figures per hectare basis. The details are presented in Table-29.

Out of the cropping systems tried the maximum net profit was realised from cashew + casuarina plot (Rs. 38,204/ha) followed by cashew+pineapple and cashew + acacia plots (Rs. 14,673 and 14,034 respectively). In the case of cashew +

pineapple plot there was no competition for the main crop. In fact growing pineapple as intercrop across the slope in trenches benefited the main crop (cashew) as evidenced by realisation of the highest yield and income (0.86 ton/ha) from main crop as compared to all the other treatments including cashew + tree species plots where the yield and income values were minimum 0.754 to 0.368 ton/ha).

The highest profit realised from cashew + casuarina combination was mainly due to the realisation of 5m long poles which fetched around Rs. 30 per pole. However, there was adverse effect on main crop as evidenced by physiological parameters.

Table 27. Yield of cashew before and after removal of intercrops and cumulative yield realised (kg/plot of 384 square metres area - six plants)

Cropping systems	5 years after planting before removal of intercrops (tree crops)	6 years after planting after removal of intercrops (tree crops)	Cumulative nut yield for the last 4 years
Cashew monocrop	5.60	7.78	20.32
Cashew+pineapple	8.80	14.37	33.07
Cashew+casuarina	4.06	6.73	14.14
Cashew+acacia	2.03	2.15	5.91
Cashew+subabul	4.12	5.44	13.50
Cashew+mucuna	4.46	8.43	19.08
Cashew+guava	5.30	5.94	17.52
CD for treatments	3.27		

Table 28. NPK and Ca content of soils under different cropping systems

Cropping system	N(%)	P ₂ O ₅ (kg/ha)	K ₂ O	Ca (ppm)
Cashew alone	0.05	4.48	106.6	112
Cashew+pineapple	0.08	37.70	84.7	112
Cashew+acacia	0.06	7.50	90.4	71
Cashew+subabul	0.08	5.72	74.5	183
Cashew+casuarina	0.10	5.26	150.8	139
Cashew+cover crop	0.12	8.96	142.2	129

Table 29. Benefit/cost analysis of cashew based cropping systems for the first seven years of planting

Cropping systems	Cumulative cost of cultivation of		Yield from main crop (t/ha)	Value (Rs.)	Yield of inter crop		Value (Rs.)	Total income from the cropping system (Rs./ha)	Net profit or loss for the first 7 years (Rs./ha)
	Main crop (1987-93) (Rs./ha)	Intercrop (1987-93) (Rs./ha)			t/ha	Nos/ha.			
Cashew alone	18193	—	0.528	12736	—	—	—	12736	-6157
Cashew+pineapple	18193	26679	0.860	20396	14.793*	4330°	39149	59545	+14673
Cashew+guava	18193	9440	0.456	10940	0.345+	—	1035	11975	-15658
Cashew+acacia	18193	10156	0.154	3688	9.40@	2392	38700	42388	+14039
Cashew+subabul	18193	9060	0.351	8374	—	910	13650	22020	-4829
Cashew+casuarina	18193	9156	0.368	8675	4.36@	1872	57468	66153	+38204
Cashew+cover crop	18193	2200	0.496	11933	—	—	—	11933	-8460

Cost of land, barbed wire fencing, supervisory charges were not included while calculating cost of cultivation.

* Pineapple fruit yield (14.793 tonnes/ha) for the first 3 years. Fresh suckers were replanted in 4th and 5th year and the yield from this second planting is yet to be realised.

° Extra pineapple suckers collected/ha from the plot

+ Fruit yield of guava in the fifth year

@ Fuel wood realised from the respective crops (intercrops) (tonnes/ha)

+ = Profit - = Loss

Agr. V : Orchard Management - Comparison of hedge and square system of planting under pruned and unpruned conditions

(M. Gangadhara Nayak and N Yadukumar)

This project was started with main objective of increasing yield/unit area by adopting optimum population through proper spacing, system of planting and pruning. The experiment was laid out in 1990 at Kemminje. The treatment details are given below:

Design : Split plot Replications-3

Treatments	Net area/plot (m²)
1. 5m x 5m square	450
2. 6.5m x 6.5m square	338
3. 8m x 8m square	384
4. 5m x 4m hedge	600
5. 6.5m x 4m hedge	520
6. 8m x 4m hedge	450

Sub plot

1. Pruned
2. Unpruned

During the period modified central leader system of pruning was imposed in sub plot treatment plots. On an average 5.8 kg of dry branches have been removed per tree to impose the above pruning treatment.

Observations on growth

During the period observations on growth like height, girth of the trunk above and below the graft joint, spread of the

canopy and ground coverage were taken. Except for the spread and ground coverage in pruned and unpruned trees the difference was not significant for all the above characteristics among different treatments (Table 30).

Photosynthesis and related parameters

Treatmentwise observations recorded using LCA-3 photosynthesis system on photosynthesis and related parameters in cashew also indicated that there was no difference among different treatments (Table-31).

The computed values for light interception by the crop canopy in each treatment indicated a direct correlation between light interception and plant population. By fourth year of planting light interception was maximum to an extent of 15.3 and 24.39 per cent in pruned and unpruned sub-plot treatments of main plot treatment (5m x 4m spacing) and it was minimum of 3.5 and 5.3 per cent in pruned and unpruned sub-plot treatments of main plot treatment (8m x 8m spacing). Pruning reduced the light interception compared to the corresponding values for unpruned plants. The above observations were taken five months after pruning.

Table 30. Observations on growth as affected by different treatments

Treatment	Mean height(m)		Mean spread (m)		Mean girth (cm)		Percent ground area covered by the crop canopy	
	Pruned	Unpruned	Pruned	Unpruned	Above graft union	Below graft union	Pruned	Unpruned
					Pruned	Unpruned	Pruned	Unpruned
5m x 5m	2.40	2.58	2.82	3.48	27.06	29.33	24.96	38.00
6.5m x 6.5m	2.27	1.94	2.56	2.72	23.06	23.73	12.16	13.68
8m x 8m	2.29	2.27	2.18	2.70	21.03	23.60	5.82	8.92
5m x 4m	2.54	2.50	2.55	3.22	23.13	25.80	25.52	40.65
6.5m x 4m	2.28	2.28	2.18	3.02	22.33	25.06	14.32	27.45
8m x 4m	2.36	2.29	2.56	2.88	24.93	27.20	16.03	16.06

Yield

Observations on initial yield/tree also indicated no difference among treatments. The plot yield per unit area, however, indicated difference among different treatments. Maximum yield was observed in

the case of 5m x 5m and 5m x 4m spacing treatments where the plant population/unit area was maximum and it was minimum in the case of treatments where the population densities were only 236 and 156 trees/ha. (Table 32).

Table 31. Physiological parameters as affected by different spacing and systems of planting

Treatment		Evaporation (m mol m ² s ⁻¹)	Leaf temp. (°C)	Stomatal conductance (mol m ² s ⁻¹)	Net photo- synthesis (P _n) (μ mol m ² s ⁻¹)	CO ₂ concn. Mol/l.	WUV (μ mol CO ₂ /m mol H ₂ O)
5mx5m	Pruned	7.7	35.0	0.52	5.8	266	0.75
	Unpruned	8.4	34.9	0.56	6.7	257	0.88
6.5m x 6.5m	Pruned	10.0	34.7	0.75	6.1	262	0.61
	Unpruned	8.4	35.0	0.64	7.4	246	0.88
8m x 8m	Pruned	8.7	33.4	0.74	6.5	263	0.74
	Unpruned	9.8	33.6	0.78	7.6	262	0.77
5m x 4m	Pruned	8.6	34.9	0.54	6.1	258	0.71
	Unpruned	8.7	33.6	0.78	7.4	262	0.77
5m x 4m	Pruned	5.8	36.1	0.55	5.8	265	1.00
	Unpruned	8.8	35.4	0.56	8.2	249	0.93
8m x 8m	Pruned	8.7	35.0	0.61	6.5	257	0.74
	Unpruned	8.0	33.0	0.70	7.1	263	0.88

Table 32. Nut yield (kg) as affected by different systems of planting under pruned and unpruned conditions

Treatment	No./ha	Yield/tree		Yield/ha	
		Pruned	Unpruned	Pruned	Unpruned
5m x 5m square	400	0.257	0.321	102.94	128.50
6.5 m x 6.5m square	236	0.196	0.235	46.41	55.73
8m x 8m square	156	0.177	0.213	27.70	33.34
5mx4m hedge	500	0.193	0.274	96.66	125.48
6.5m x 4m hedge	384	0.212	0.256	81.50	75.43
8m x 4m hedge	312	0.215	0.231	67.16	72.10

Agr. VI : Development of suitable cashew based cropping systems

(N Yadukumar and B Nagaraja)

Two experiments namely, cashew with forest tree species and cashew with fruit crops were laid out at Kemminje and Shantigodu respectively after clear-felling of existing cashew trees and forest tree species in 1990, to evolve suitable cashew based cropping systems. In the intercropped plots, cashew was planted in single hedge row with a spacing of 10m x 5m. The fruit crops, as intercrops were also planted adopting the same spacing exactly in the middle of four cashew plants. Net plot size was 300 sq.m for cashew with intercrops. Although the spacing for cashew remained the same (10m x 5m) in plots intercropped with forest species, the spacing adopted for planting forest species (as intercrops) varied. Hence, the population of forest species per plot of 300 sq.m ranged from 6 to 78 (Table 33). Details of spacing adopted in this cashew based cropping system is given in Table 34.

Cashew with forest species

Growth characters: Observations on growth characteristics showed that growing forest tree species with cashew did not affect girth, height, spread and ground coverage even after four years of planting (Table-33).

Physiological parameters: Growing forest species with cashew had no significant effect on photosynthesis, PAR and transpiration of the main crop. When tall tree species like acacia and casuarina are grown with cashew, the values for PAR and net photosynthesis tend to reduce though not significantly (Table-35).

Yield

The nut yield (kg/plot and kg/ha) three years after planting showed no significant difference among treatments except in high

Table 33. Growth characteristics of cashew as affected by growing forest species in the interspace

Treatment	Population/ plot (300 sq.m)	Girth (cm)	Height (cm)	Spread (cm)	Ground coverage	
					m ²	%
Cashew+casuarina+acacia	6+12+13	22.86	203	273	5.83	11.6
Cashew+acacia+casuarina	6+7+14	25.40	245	314	7.75	15.2
Cashew+ailanthus	6+32	33.53	216	326	8.34	16.7
Cashew+bamboo	6+6	32.0	231	360	10.19	20.3
Cashew high density	12	32.51	219	330	8.54	34.2
Cashew+subabul	6+78	33.02	231	325	8.35	16.6
Cashew alone	6	33.27	221	329	8.51	17.0
CD		6.25	NS	NS	NS	

density plot. This treatment registered maximum yield (124 kg/ha) mainly due to the existence of double the population (400 trees/ha). In all other treatments, the population of cashew trees was only 200/ha (Table 36).

Cashew with fruit crops

In spite of utmost care taken, the fruit crops like custard apple (sitaphal) and ber have not established well. The fruit crops like aonla, garcinia and pomegranate are coming up fairly well.

Table 34. Spacing of intercrops in cashew based cropping systems with forest species.

Cropping system	Forest species	Spacing within the row (m)	Spacing between two rows (m)	Spacing between paired rows (m)
Acacia + Casuarina	Acacia	2.50	10.0	—
	Casuarina	2.50	2.5	7
Casuarina + Acacia	Casuarina	1.25	10.0	—
	Acacia	2.50	2.5	7
Ailanthus	Ailanthus	2.50	2.5	7
Subabul	Subabul	1.25	1.25	5
Bamboo	Bamboo	5.00	10.0	—

Note: The spacing adopted for main crop (cashew) is 10m x 5m in all the cropping systems, whereas, in high density cashew planting it is 5m x 5m.

Table 35. Photosynthesis, PAR, transpiration, stomatal conductance as affected by growing forest species in cashew orchard

Treatment	PAR (μ mol $m^{-2}s^{-1}$)	PN (μ mol $CO_2 m^{-2} s^{-1}$)	Transpiration (M mol $H_2O m^{-2} s^{-1}$)	Cs (Mol $m^{-2} s^{-1}$)	CO ₂ concentration (ppm)
Cashew+casuarina+ acacia	758	7.02	6.1	0.38	241
Cashew+acacia+ casuarina	724	5.83	7.1	0.30	240
Cashew+ailanthus	1333	8.57	9.1	0.53	256
Cashew+bamboo	1320	7.60	8.9	0.66	260
Cashew+subabul	802	7.32	6.2	0.23	220
Cashew high density	1350	8.30	7.0	0.33	224
Cashew alone	1357	8.25	6.3	0.30	208
CD	191	2.80	1.03	0.123	

Table 36. Cashewnut yield (kg/plot and kg/ha) as affected by growing tree species with cashew

Treatment	Nut yield (kg/plot of 300 sqm)	Nut yield (kg/ha)
Cashew+casuarina+acacia	2.08	69.32
Cashew+acacia+casuarina	1.81	60.66
Cashew+ailanthus	2.30	76.65
Cashew+bamboo	1.90	63.32
Cashew high density	3.75	124.98
Cashew+subabul	2.02	67.32
Cashew alone	2.82	93.99
CD	0.596	

Agr. VII : Comparative efficacy of slow release nitrogenous fertilizers for cashew

(N. Yadukumar)

The experiment was laid out in 1990 by planting M 44/3 cashew grafts. During the period, the recommended treatments were imposed except treatment no. 9 and 10 as lac coated urea was not available. Hence, inclusion of this fertilizer was dropped from the experiment.

Treatments

Application of fertilizer 500g N, 125g each of P_2O_5 and K_2O /tree/year in the forms as described below. The fertilizer dose from 1 to 10 also has 125g each of P_2O_5 and K_2O /tree/year besides urea.

1. Urea in two split doses/year
2. Urea in one application
3. Urea in perforated polybags once in a year
4. Urea in perforated polybags once in two years.
5. Urea formaldehyde once in a year

6. Urea formaldehyde once in two years
7. Neem coated urea once in a year
8. Neem coated urea once in two years
9. Lac coated urea once in a year
10. Lac coated urea once in two years
11. NP tablet once in a year and 125g K_2O in the form of muriate of potash
12. NP tablet once in two years and 125g K_2O in the form of muriate of potash

NPK and Ca content of soil before imposing the treatments were analysed and presented in Table-37.

Table-37. NPK and Ca content of soil before imposing treatment

Nutrient	Content
N (%)	0.01
P_2O_5 (Kg/ha)	9.50
K_2O (Kg/ha)	107.00
Ca (ppm)	110.00

Phy. III : High density planting of cashew

(N. Yadukumar)

This experiment was initiated in 1982 to assess the effect of different plant densities on growth and yield.

Thinning

As there was not much improvement by removing overlapping branches every year right from eight years after planting in the case of 4m x 4m spaced trees as

compared to previous years yield, it was decided in the Research Council meeting to thin out the population to 50 per cent by adopting diagonal method of thinning. Accordingly after recording yield in 1993 (11 years after planting), the thinning was done in July 1993. Total fuel wood recovered after this thinning operation is given in a Table 38.

Yield

Maintaining a plant density of 278 trees/ha (6m x6m spacing) gave the highest yield (475 kg/ha) as compared to other treatments. Cumulative yield data from

4 to 11 years after planting, however, showed that maintaining a population of 625 trees/ha (4m x 4m spacing) gave the highest yield of 4.238 t/ha (Table-39).

Table-38. Total fuel wood recovered after thinning

Original spacing (m)	Original population	Spacing after thinning (m)	Population after thinning	Total fuel wood recovered (t/ha)
4 x 4	625	8x5.65x5.65	312	24.84

Table 39. Yield recorded 11 years after planting

Treatment	Spacing (m)	Population (No./ha)	Yield kg/ha (11 yrs after planting)	Cumulative yield (kg/ha)
T-1	8x8	156	313	1842
T-2	6x6	278	475	2481
T-3	4x4	625	460	4238
T-4	3x 3 upto 7 yrs and 6x4.25x4.25 after that	1111 (upto 7 yrs) 555 (after 7 yrs)	234	3953
T-5	2x2 upto 7 yrs and 4x4 after that	2500 (upto 7 yrs) 625 (after 7 yrs)	269	3687
CD		112.21		

Hort. IV : Studies on off - season graft production in cashew

(M Gangadhara Nayak and KRM Swamy)

This project was initiated for finding out the possibility of producing soft wood grafts during off-season (flushing, flowering and fruiting season) and also for improving the graft success during summer months.

Soft wood grafting with green scions

Soft wood grafting using immature (green) scion sticks of 45 and 60 days age was carried out and the graft success was recorded (Table 40). Graft success with

Table 40. Graft success with immature green scion sticks

Month of grafting	Per cen success with	
	45 days old scion sticks	60 days old scion sticks
Nov	36.00	58.00
Dec.	45.00	63.00
Jan.	48.00	68.00
Feb.	42.00	53.00
Mean	42.00	60.00

100 grafts were produced in each month

green scion sticks of above 60 days was 60.5 per cent. The soft wood grafts produced on commercial scale utilising the green scion sticks of above 60 days also gave a mean graft success of 56.5 per cent (Table 41) which is comparable to that of grafts produced with matured scion sticks.

Soft wood grafting with decapitated scions

Soft wood grafts prepared by utilizing decapitated green scion with flower panicles, matured scions with damaged terminal portion, and matured scions with sprouted terminal buds gave fairly a good graft success (Table-42).

Table 42. Graft success with decapitated lateral shoots as scion sticks

Type of scions used	Treatment	Month of grafting	No. of grafts prepared	Per cent success
Green scions with flower panicles	Flower panicles were cut	Nov	100	50
		Jan	100	52
			200	51
Mature scions with damaged terminal portion	Damaged portion was cut	Nov	100	50
		Feb	100	50
			200	50
Mature scions with terminal bud sprouted on the mother tree	Sprouted terminal portion were cut	Nov	100	58

Table 41. Graft success with green scion sticks on commercial scale

Month of grafting	No. of grafts prepared	Graft success	
		Number	per cent
Nov	3225	1850	57.3
Dec	6110	3244	53.0
Jan	5935	3750	63.1
Feb	3375	1700	50.3
Total	18,645	10,544	56.55

Soft wood grafting under low cost humidity chamber

Soft wood grafting under low cost humidity chamber was also continued during drier months (Jan-May) to find out the possibility of increasing the graft success. A set of grafts prepared by normal method with a polythene cap on individual graft was used as control and the results are presented in Table 43. The graft success under normal method and the low cost humidity chamber was similar. The grafts produced under low cost humidity chamber, however, were early in sprouting and vigorous in growth.

Table 43. Graft success under low cost humidity chamber

Month of grafting	Under normal method		Under low cost humidity chamber	
	No. of grafts prepared	No. of successful grafts	No. of grafts prepared	No. of successful grafts
Jan	100	68.00	150	95.00
Feb	100	65.00	150	72.00
Mar	100	57.00	100	65.00
Apr	100	72.00	100	59.00
Total	400	262.00	500	291.00
% Success	—	65.50	—	58.20

Hort. V : Root stock studies in cashew

(M Gangadhara Nayak and KRM Swamy)

This project was initiated with an objective of screening the root stocks for dwarfing.

Dwarfing root stock could not be identified by employing the morphological

and anatomical features such as height of the seedling, girth at collar region, number of leaves, internodal length, total phenols, stomatal count and bark percentage in root and shoot. During the field survey for germplasm collection a semi-dwarf type was

Table 44. Morphological observations on six month old seedlings raised from seeds collected from semi dwarf trees at Vittal and bulk seeds received from Brazil

Name	Source of collection	Wt. of seeds (g)	Height of seedling (cm)	Internodal length (cm)	No. of leaves/seedling
Brazil-I	Brazil	12.2	47.2	1.95	24.2
Brazil-II	Brazil	8.6	62.4	2.44	25.6
Brazil-III	Brazil	5.7	54.6	2.04	26.8
H. Gollahalli-1	Mulabagal Taluk (Kolar Dist)	6.0	34.4	1.37	25.0
S 11/1	CPCRI (RS), Vittal	4.3	32.4	1.31	24.6
S 11/2	CPCRI (RS), Vittal	4.6	22.3	1.03	21.6
VTH 762/2	CPCRI (RS), Vittal	3.5	16.0	0.92	17.3
VTH 762/4	CPCRI (RS), Vittal	3.5	16.6	0.86	19.2

located in Mulubagalu taluk of Kolar district. Also a few samples from Brazil were collected through Kerala Nut Food Company, Kollam. These types were evaluated along with the semi-dwarf types of CPCRI Regional Station, Vittal.

Seedlings were raised in polythene bags and the morphological observations are recorded on six month old seedlings. The observations indicated a clear cut difference with respect to height of the seedling and internodal length (Table 44). The height of the seedling varied from 47.2 cm to 62.4 cm and the internodal length varied from 1.95 to 2.44 cm in the case of seedlings from Brazilian origin while the height of seedlings ranged from 16.0 cm to 34.4 cm and the internodal length from 0.86 cm to 1.37 cm in the case of semidwarf types. The number of leaves, however, did not differ.

During August 1993, eight month old seedlings of the above types were planted in the field for evaluation. The plants of

Brazilian origin remained vigorous in growth, even after four months after planting (Table 45). The plants will be maintained in the field for further evaluation.

Table 45. Mean height of the seedlings after four months of planting

Name	Source of seed collection	Mean height of seedlings (cm)
Brazil-I	Brazil	61.8
Brazil-II	Brazil	60.3
Brazil-III	Brazil	66.1
H. Gollahalli-1	Mulabagal Taluk (Kolar Dist)	61.8
S 11/1	CPCRI (RS), Vittal	44.4
S 11/2	CPCRI (RS), Vittal	44.3
VTH 762/2	CPCRI (RS), Vittal	27.0
VTH 762/4	CPCRI (RS), Vittal	37.5

Hort. VI : Comparing the economics of top working with replanting of cashew

(KRM Swamy and PS Bhat)

The objective of the project is to compare the economics of top working with replanting of cashew. The cost of establishment and maintenance of top worked plot and replanted plot during the last four years was Rs. 19,350 and Rs. 14,790 per hectare, respectively.

Trial at Shantigodu

Thirty cashew trees, aged 14 years

were top worked with VTH 30/4 by adopting soft wood grafting technique (0.2 ha plot) during sept-oct., 1990. In the adjacent plot old cashew trees were completely removed and fresh planting was taken up with 30 soft wood grafts of VTH 30/4. Of the 30 top worked trees, 11 trees died due to stem and root borer infestation during 1990-91. Swabbing the trunk portion of the top worked trees upto one meter height from ground

level with carbaryl (0.2%) was taken up once in three months as a prophylactic treatment against stem and root borer. No fresh infestation of stem and root borer was observed. During the year growth parameters and yield data were recorded. In the case of top worked trees, the shoot length ranged from 200-500cm with a mean of 368 cm and the shoot girth above the graft joint ranged from 15 to 39 cm with a mean of 30.7 cm (Table-46). In the case of replanted grafts, the plant height ranged from 200-300 cm with a mean of 220 cm and the trunk girth (15 cm above ground level) ranged from 19 to 30 cm with a mean of 23.8 cm (Table 46). The yield of top worked plot and replanted plot was 34.37 kg and 10.00 kg, respectively. The yield of top worked trees ranged from 0.98 to 2.90 kg/tree with a mean of 2.14 kg/tree.

Table 46. Shoot length and girth in top worked trees and plant height and girth in grafted plants during Dec 1993

Plot	Shoot length/ plant height (cm)	Shoot girth/ plant girth (cm)
Top worked plot		
Min.	200	15.0
Max.	500	39.0
Mean	368	30.7
Replanted plot		
Min.	200	19.0
Max.	300	30.0
Mean	220	23.8

The mean yield of replanted grafts was 0.33 kg/plant. The cost of establishment and maintenance of 0.2 ha top worked plot and 0.2 ha replanted plot during the last four years was Rs. 3870 and Rs. 2958 respectively (Table 47).

Table 47. Cost of establishment and maintenance of top worked plot and replanted plot during the last four years

Year	Amount spent (Rs.)	
	Top worked plot	Replanted plot
1990-91	1241	620
1991-92	845	530
1992-93	955	808
1993-94	829	1000
Total/plot	3870	2958
Total/ha	19,350	14,790

On Farm Trial at Kunthur

During May 1992, an on-farm trial of top working was initiated in the KCDC plantation at Kunthur. Sixty cashew trees aged 11 years, were top worked with VTH-170. During the first year, very high mortality (80%) of the top worked trees was observed due to stem and root borer infestation, resulting in the loss of 48 trees. Of the 12 surviving top worked trees, five died during this year due to stem and root borer infestation. Swabbing the trunks with carbaryl (0.2%) was taken up once in three months as a prophylactic treatment against stem and root borer.

Hort. VII : Pruning studies in cashew

(M Gangadhara Nayak)

This project was initiated to study the effects of pruning on dwarfing and canopy containment, flushing and flowering behaviour, and branching habit. Further, it also envisages to understand the mechanism of yield improvement due to leader shoot pruning.

A field trial with four cashew varieties viz. VRI-1 (intensive branching and early flowering type), Ullal-1 (intensive branching and late flowering type), NRCC Selection 1 (extensive branching and late flow-

ering) and VTH 30/4 (extensive branching and early flowering type) has been laid out at Experimental Station, Shantigodu, with three replications in a completely Randomised Block Design (RBD).

During the year 1994 modified leader system of training will be imposed to all the plants. The leader shoot pruning treatments will be imposed from next year since the plants have not put forth sufficient vegetative growth.

CROP PROTECTION

Attempts have been made for developing an Integrated Pest Management Package against stem and root borers and to evolve effective chemical and biological control measures for tea mosquito and other sucking pests. Prophylactic control trial against stem and root borers (*placaederus ferrugineus*) was repeated and no incidence was recorded after completion of four rounds of application with commercial neem formulations. A new egg parasitoid *Gonatocerus* sp. nr. *bialbifuniculatus* Subba Rao on eggs of TMB and two redvid predators (*Panthous bimaculatus* Dist., and *Sycanus collaris* Fab.) were recorded. Life cycle and feeding potential *Sycanus collaris* (Fab.) have been studied. Feeding deterrance property was noticed in commercial neem pesticides when tested against tea mosquito bug.

Ent. V : Developing integrated pest management package against cashew stem and root borers *Plocaederus ferrugineus* L.

(PS Bhat and TN Raviprasad)

The aim of the project is to standardize various components of pest management practices namely, prophylactic, curative, biological and mechanical methods against cashew stem and root borers for developing an Integrated pest management package.

1. Prophylactic control trial

The results of trial conducted during 1992-93 showed that neem oil (6%) was most effective in reducing the pest incidence. Along with neem oil, four commercially available neem based pesticides were also evaluated for their efficacy. The pesticides were applied to the base of tree trunk upto one metre height and to the exposed roots once in three months. There was no incidence of stem borer with Nimbecidine and Limanool after four rounds of treatment, whereas, the incidence was only 4 per cent with Godrej Achook, RD-9 Repellin and neem oil. (Table 48)

2. Curative control experiment

This experiment was taken up to find out alternate insecticide to BHC, a commercially used insecticide in managing cashew stem and root borer. Different treatments imposed after mechanical extraction of grubs and recovery of the trees thereafter is presented in Table 49. Trees at the initial stages of infestation responded to the treatments and 80 per cent of the trees recovered after carbaryl swabbing (0.2 per cent) combined with soil application around the base with Sevidol G (75g/tree). Trees with middle and advanced stages of infestation failed to recover even though the treatment was given after complete grub extraction.

3. Biological control studies

(a) Working out LC_{50} for *Beauveria bassiana* : Using Finney's method of probit analysis LC_{50} (Median Lethal Concentration) was worked out for most virulent fungal

Table 48. Prophylactic control against cashew stem and root borers *Plocaederus ferrugineus*

Treatment	Per cent trees attacked after				Cost (Rs/ tree/ round)
	I	II	III	IV	
Nimbecidine (0.5%)	0	0	0	0	2.25
Lamanool (0.5%)	0	0	0	0	2.22
Godrej Achook (0.5%)	0	0	0	4	2.10
RD-9 Repellin (0.5%)	0	0	4	4	2.10
Neem oil (6%)	0	0	4	4	2.10
Control	0	0	4	8	—

Table 49. Curative control of cashew stem and root borers *Plocaederus ferrugineus*

Treatment	Early stage of infestation		Middle/advanced stage of infestation	
	No. of trees treated	Per cent recovery	No. of trees treated	Per cent recovery
Chlorpyriphos (0.2%)	10	70	5	0
Carbaryl (0.2%)	10	70	5	20
Carbaryl (0.2%) + Servidol	10	80	5	0
G (75 g/tree)				
Limanool	10	70	5	0
Control	10	10	5	0

pathogen *Beauveria bassiana*. The pathogen was multiplied on jowar grains and 15 day old spawn was used for experimental purpose. Spore suspension was prepared in distilled water using Tween 80 as spreading agent. The highest and lowest concentrations used were 2.6×10^8 and 2.6×10^4 respectively, with a dilution rate of 10^{-1} . The spore suspension was topically applied over the grub using an atomiser. The mortality of grubs at different concen-

trations tried is presented in Table-50. The empirical probit values for mortality in each concentration was obtained by Finney's table. These values were plotted against log concentration to obtain provisional probit regression line (Fig. 1). Further, the expected probit values, expected mortality and working probit were calculated (Table 50). Final probit regression line was drawn (Fig. 2) with the regression equation $y = 1.74+0, 0.53x$ (where $y =$ probit mortality

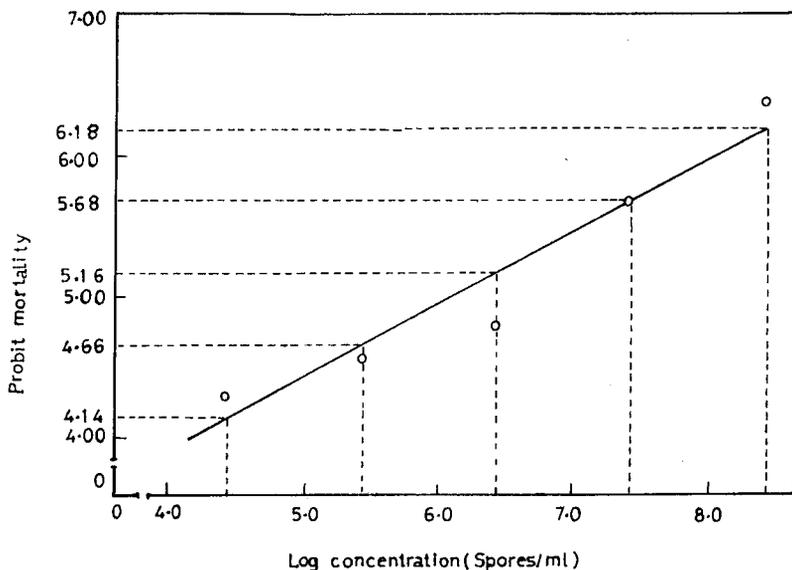


Fig. 1: Provisional Probit regression line for *Beauveria bassiana*

Table 50. Mortality, log concentration and probit analysis for *Beauveria bassiana*

Dose (spores/ml)	Mortality	Log conc.	Emperical probit	Expected		Working probit
				Probit	Mortality (%)	
2.6×10^8	91.67	8.42	6.38	6.18	88.1	6.36
2.6×10^7	75.00	7.42	5.68	5.68	75.2	5.67
2.6×10^6	41.67	6.42	4.79	5.16	56.4	4.79
2.6×10^5	33.33	5.42	4.57	4.66	36.7	4.57
2.6×10^4	25.00	4.42	4.33	4.14	19.5	4.35

and x = log concentration). Homogeneity of the data was tested by chi square (χ^2) test and fiducial limits (lower limit (LL) and upper limit (UL)) of LC_{50} was also calculated which was found to be 1.41×10^6 spores/ml with 0.31×10^6 spores/ml as lower limit and 6.53×10^6 spores/ml as upper limit.

(b) Survey of natural enemies: An unidentified egg parasitoid collected from

eggs of *Plocaederus ferrugineus* at KCDC plantations, Koila, has been sent for identification.

4. Light trap and trap crop studies

Adults were not attracted to the mercury light trap. Silk cotton plants raised as trap crop nearby cashew plantations are being maintained.

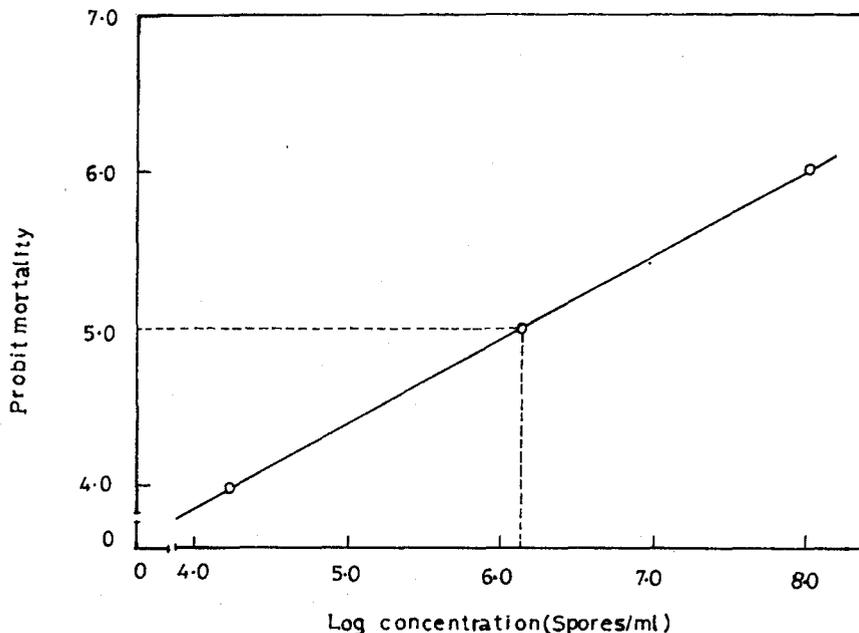


Fig. 2: Final probit regression line for *Beauveria bassiana*

Ent. VI : Biological control of tea mosquito bug, *Helopeltis antonii* Sign. (Hemiptera : Miridae) and other sucking pests of cashew

(D Sundararaju (upto 31 May 1993) and TN Raviprasad)

The project aims to study and evolve biological control measures for developing IPM for tea mosquito bug (*Helopeltis antonii* Sign.) and other sucking pests of cashew.

(a) (i) Survey for natural enemies of TMB

Multi-locational surveys were conducted with a view to find out the existence of egg/nymphal/adult parasitoids on TMB. Collection and dissection of the eggs of TMB were done to observe emergence of parasitoids along with collection of abnormal/sluggish nymphs and adults for confirming parasitisation.

Emergence of egg parasitoid *Teleonomus* sp. occurred at varying levels while, nymphs and adults developed normally indicating absence of parasitisation (Table 51). For the first time among the natural enemies, a new egg parasitoid *Gonatocerus* sp. nr. *bialbifuniculatus* Subba Rao on eggs of TMB and two reduvid predators viz. *Panthous bimaculatus* Dist. and *Sycanus collaris* (Fab.) were found preying on nymphs and adults of TMB.

(ii) Studies on seasonal occurrence of parasitoids during cropping season

The extent of parasitization of TMB eggs was recorded from Jan to May 1993 which ranged from 12.6 to 50.0 per cent. Despite higher parasitization, the emergence of adult parasitoids was not observed in some of the weeks possibly due to drying of plant tissues containing host eggs. This

indicates that the host eggs should be maintained in its natural condition for proper development of parasitoids (Table 52).

(iii) Studies on extent of field parasitisation of exposed host eggs

Viable eggs of TMB in cashew seedlings were placed under field conditions to attract parasitisation and observations were recorded from Jan-April. The highest parasitisation occurred during April 1993. Adult parasitoid did not emerge (Table 53)

(b) Developing an artificial diet packet for TMB

Trials were conducted to develop an artificial semiliquid diet. The diet was placed in a turgid membranous packet to facilitate piercing and sucking without leaking and also providing a substratum for egg laying. Solutions evaluated for phagostimulatory effect were (a) sucrose solution (1.0%); (b) sucrose solution (5.0%); (c) water extract of cashew shoots (10g in 150 ml distilled water) and a:c and b:c in equal proportion (1:1). These were taken in 5 x 5 cm parafilm sachets and kept for feeding by *H. antonii* adults.

The details of keeping quality and survival of adults of *H. antonii* are given in Tables 54 and 55. As the adults could not perceive necessary feeding stimulus, thinner and gas permeable membranes are to be tried further.

Table 51. Details of parasite emergence from eggs of TMB collected from different locations

Month of sampling		Location	Total No. of eggs collected	% parasitisation
Feb.	93	Panemangalore	138	16.7 (1.5)
		Konaje	92	25.0 (16.3)
Apr.	93	Panemangalore	77	23.4
		Konaje	38	42.1 (2.6)
		Ullal*	30	46.7 (13.3)
		Shantigodu	149	35.6 (1.3)
		Adyanadka	89	40.5 (7.9)
May	93	Ariyapu	61	49.2 (1.6)
Jun.	93	Mani*	34	14.7
		Panemangalore	54	16.6
		Konaje	100	14.0
Jul.	93	Mani	32	18.7
		Panemangalore	46	21.8
		Konaje	99	161
Aug.	93	Mani	26	26.9
		Panemangalore	41	26.8
		Konaje	66	19.5
Sept.	93	Mani	19	15.7
		Panemangalore	28	21.4
		Konaje	60	15.2
Oct.	93	Mani	10	30.0
		Panemagalore	19	26.3
		Konaje	44	11.2
Nov.	93	Mani	6	0.0
		Panemagalore	14	14.2
		Konaje	38	13.1
Dec.	93	Mani	8	0.0
		Panemagalore	12	0.0
		Konaje	38	2.5
Jan.	94	Mani	30	13.3
		Panemagalore	22	0.0
		Konaje	44	4.5

* Plots treated with insecticides
 Figures in parentheses indicate per cent of fully emerged + dead adult parasitoids

(c) Studies on ant exclusion using sticky band traps

The movement of ants in the canopy obstructs and disturbs the parasite activity. Therefore, in the present trials the

effect of arresting ant movement in cashew canopy on parasite efficiency was evaluated.

The main trunk was banded using

Table 52. Seasonal occurrence of egg parasitoid, *Telenomus* sp. during cropping season of cashew

Month		Weeks				Total No./ Average % Max. No. of days for emergence
		First	Second	Third	Fourth	
Jan. 93	TE	98	<u>133</u>	165	102	396
	TP	22.5 (9.2) 2c	<u>21.8</u> (6.0) 1c	32.1 (7.9)	37.3 (4.9)	28.4 7.0
	D	23	13	23	—	23
Feb. 93	TE	137	<u>115</u>	128	68	448
	TP	45.3 (29.2) 5c	<u>25.2</u> (3.5)	18.0 (1.6)	16.2 (2.9) 3c	26.2 (9.3)
	D	33	20	8	15	33
Mar. 93	TE	66	<u>119</u>	61	89	335
	TP	30.3 (7.6) 7c	<u>12.6</u> (1.7) 3c	13.1 —	14.6 (1.1)	17.7 (3.5)
	D	32	—	—	9	32
Apr. 93	TE	68	<u>103</u>	55	69	295
	TP	26.5 (7.4) 1c	<u>29.1</u> (1.9)	45.5 1c	47.8 —	37.2 2.3
	D	24	16	—	—	24
May. 93	TE	65	<u>61</u>	82	50	258
	TP	29.2 (1.5)	<u>49.2</u> (1.6)	28.1 (1.2)	50.0 (4.0)	39.1 2.1
	D	—	18	—	6	18

TE = Total number of eggs observed

TP = Total percentage of parasitisation

D = Number of days taken for emergence of last parasitoid.

Fig. in parentheses indicate % of parasitisation showing adult parasitoids (fully emerged + dead adults)

C = Number of adult parasitoids of *Chaetostricha* sp.

Total number of eggs underlined indicate that number of eggs collected after chemical control

a sticky trap, and branches touching other trees on the ground were cut of to prevent ants thereby completely arresting the ants movement and was found to be effective

for seven months. Eggs of *H. antonii* were collected and observed for extent of parasitisation in treated and untreated trees. (Table 56)

Table 53. Extent of parasitisation in the field exposed eggs during different months in 1993.

Month	No. of eggs exposed	% of parasitisation observed upto 45th day	% of parasitisation observed after 45th day	Total % of parasitisation
Jan.	86	—	—	—
Fab.	57	3.5	1.8	5.3
Mar.	101	2.0	2.0	4.0
Apr.	67**	—	37.3	37.3

* Oviposition by adult parasitoids of *Telenomus* sp. was visually confirmed

** Plant parts containing eggs were removed on the 15th day after oviposition

Table 54. Survival of *H. antonii* released on different artificial diet sachets

		% adults alive after		
		6 hr	12 hr	24 hr
(a)	Sucrose solution (1.0%)	100.0	40.0	0.0
(b)	Sucrose solution (5.0%)	80.0	0.0	0.0
(c)	Water extract of cashew shoots	100.0	0.0	0.0
a : c	(1 : 1)	100.0	20.0	0.0
b : c	(1 : 1)	100.0	0.0	0.0

Table 55. Observations on keeping quality of different artificial diets

Artificial diet	24 hr	Period after sacheting		
		48 hr	72 hr	96 hr
Sucrose solution (1.0%)	Normal	Normal	Fermented	Fermented
Sucrose solution (5.0%)	Normal	Normal	Normal	Fermented
Water extraction of cashew shoot	Normal	Normal	Precipitated	Spoiled
a : c (1 : 1)	Normal	Normal	Precipitated	Spoiled
b : c (1 : 1)	Normal	Normal	Normal	Precipitated

(d) Laboratory studies on a reduviid predator of TMB, *Sycanus collaris*:

The life cycle and feeding potential of *Sycanus collaris* were studied under laboratory conditions. The life cycle was

completed in 60-72 days from egg hatch to final moulting with five nymphal instars. The feeding potential increased from second instar onwards and each predator fed on 241.4 nymphs in its life cycle (Table 57).

Table 56. Effect of ant exclusion on egg parasitisation and damage score (1993-'94).

Month of sampling	Trap banded		Unbanded control		Mean damage score	
	No. of eggs collected	% parasitisation	No. of eggs collected	% parasitisation	Trap banded	Unbanded control
Sept.	10	20.0	14	14.3	—	—
Oct.	16	31.3	22	22.7	3.5	4.0
Nov.	8	25.0	11	9.1	2.8	3.5
Dec.	15	20.0	17	17.6	2.0	3.5
Jan.	5	0.0	12	0.0	2.0	2.8
Feb.	8	0.0	14	0.0	2.5	3.0
Mar.	7	0.0	9	0.0	2.0	2.5

Table 57. Feeding potential of *Sycanus collaris* (Reduviidae) on nymphs and adults of tea mosquito bug

Stage	Duration (in days)	Prey composition	
		Total	Daily mean
Egg	26.5	—	—
Nymph-I	5.2	12.0	2.3
Nymph-II	9.8	19.8	2.0
Nymph-III	10.3	32.0	3.1
Nymph-IV	14.6	44.6	3.1
Nymph-V	22.5	56.0	2.5
Adult	45.0	77.0	1.7
Total	133.9	241.4	—

Ent. VIII: Testing the efficacy of plant products against tea mosquito bug *Helopeltis antonii* Signoret

(P.S. Bhat)

This project is aimed at testing efficacy of various plant products possessing insecticidal properties against tea mosquito bug, *Helopeltis antonii* S. Tests were conducted to find out oviposition deterrence, ovicidal action (hatchability of egg) and growth regulatory properties of pongamia oil and neem based pesticides.

Oviposition deterrence

Three day old gravid females were allowed to lay eggs on cashew seedlings with tender flushes and number of eggs laid were counted after 48 hr of release. The results are presented in Table-58. There

was marked reduction in number of eggs laid in most of the treatments.

Ovicidal action

The eggs laid on treated seedlings were observed for hatching upto 10 days after treatment. The egg hatch in each treatment and respective control is presented in Table-59. No marked difference in hatchability of egg between treatment and control was noticed indicating no ovicidal action.

Mortality before completion of life cycle

The nymphs after hatching were transferred to young shoots treated with

Table 58. Oviposition deterency of pongamia oil and neem based pesticides

Name	Average no. of eggs/female in		% reduction over control
	Treated	Untreated seedling	
Pongamia oil (2.5%)	4.7	11.2	58.04
Neem oil (2.5%)	4.6	10.1	54.45
Nimbecidine (1%)	9.7	14.7	34.01
Godrej Achook (1%)	9.2	11.2	17.12
Limanool (1%)	7.2	16.2	55.56
RD-9 Repellin (1%)	8.2	11.5	28.70

Table 59. Hatchability of eggs in different plant products

	Percent egg hatch in		% reduction over control
	Treated	Control	
Pongamia oil	92.30	95.06	2.90
Neem oil	87.10	92.31	5.64
Nimbecidine	92.68	98.10	5.52
Godrej Achook	94.35	98.39	3.90
Limanool	93.88	100.00	6.12
RD-9 Repellin	98.05	100.00	1.92

Table 60. Mortality of nymphs before completion of life cycle in different treatments

Name	Percent mortality in		Difference over control (%)
	Treated	Control	
Pongamia oil	46.15	21.60	24.55
Neem oil	33.33	16.07	17.26
Nimbecidine	28.17	9.51	18.66
Godrej Achook	33.33	21.34	11.99
Limanool (1%)	25.00	18.68	6.32
RD-9 Repellin	35.00	29.23	5.79

the product to be tested. The mortality of nymphs in different treatment is presented in Table-60. A slightly higher value in all the treatments was observed as compared to the control.

Growth regulatory property

Normal life cycle pattern in all the treatments was observed and the duration was at par in comparison to the control (Table 61).

Knock down action and residual toxicity

The nymphs were released into cages containing treated seedlings to study the knock down action. For studying residual toxicity, nymphs were released 3 and 7 days

after treatment. The results obtained after 48 hr of release are presented in Tables 62 and 63. Most of the products tried were ineffective in knock down action and residual toxicity to bring about mortality of nymphs.

Feeding deterrence properties

The feeding injury made by tea mosquito bug on shoot, mid rib and lamina was graded to find out the feeding deterrence properties of commercial neem pesticides. The results are presented in Tables 62 and 63. The damage rating was much higher as compared to treated control (monocrotophos 0.05%). However, the rating was lower than the untreated control indicating feeding deterrence properties.

Table 61. Effect of different botanical pesticides on duration of life cycle of tea mosquito bug

Name	Duration of life cycle (days)	
	Treated	Control
Pongamia oil	21.67	19.75
Neem oil	21.00	21.50
Nimbecidine	19.33	20.33
Godrej Achook	19.00	19.00
Limanool	21.50	21.33
RD-9 Repellin	21.00	20.33

Observational trial with Carbaryl Flo

The experiment conducted for evaluating the efficacy of Carbaryl Flo along with some other pesticides during 1992-93 was

repeated. The results are presented in Table 64. In checking TMB, carbaryl Flo was found to be as effective as carbaryl WP.

Table 62. Knock down action and feeding deterrence of neem pesticides against tea mosquito bug

Treatment	% mortality	Damage score on		
		shoot	Midrib	Lamina
Nimbecidine	0.00	2.00	1.26	1.96
RD-9 Repellin	0.00	2.44	0.89	1.15
Godrej Achook	5.56	3.00	2.22	1.82
Limanool	11.11	2.66	1.70	1.41
Monocrotophos	100.00	0.33	0.11	0.15
Control	0.00	3.22	2.93	2.22

Table 63. Residual action of commercial neem pesticides against tea mosquito bug

Treatment	3 days after treatment				7 days after treatment			
	% mortality	Damage score on			% mortality	Damage score on		
		Shoot	Midrib	Lamina		Shoot	Midrib	Lamina
Nimbecidine	0.00	3.00	1.63	1.96	0.00	3.11	1.52	1.85
RD-9 Repellin	0.00	2.77	1.47	1.70	0.00	3.00	1.33	1.79
Godrej Achook	0.00	3.00	2.29	2.03	0.00	3.11	2.37	1.92
Limanool	5.56	3.00	1.81	1.92	0.00	3.00	1.88	1.85
Monocrotophos	100.00	0.00	0.00	0.15	100.00	0.55	0.11	0.15
Control	0.00	3.11	2.67	2.22	0.00	3.11	2.67	2.25

Table 64. Efficacy of carbaryl Flo and other insecticides against tea mosquito bug

Treatment	Damage before treatment		Damage 30 days after					
	%	Score	First spray		Second spray		Third spray	
			%	Score	%	Score	%	Score
Carbaryl NP (0.1%)	10.15	0.27	15.52	0.35	14.05	0.96	11.76	0.42
Carbaryl Flo (0.1%)	4.00	0.09	17.34	0.40	10.64	0.28	8.60	0.24
Endosulfan (0.05%)	7.25	0.20	43.61	1.28	45.05	1.41	28.29	0.86
Chlorpyrifos (0.05%)	16.94	0.47	43.75	1.27	51.23	1.39	41.00	1.32
Malathion (0.1%)	6.96	0.43	14.83	0.48	40.80	1.34	31.30	0.99
Phorate sachets	7.97	0.18	51.69	1.56	65.76	1.53	72.13	2.04
Control	10.53	0.36	41.34	1.21	72.35	2.25	61.48	1.90

Ent. IX : Standardisation of mass rearing technique for cashew stem and root borer *Plocaederus ferrugineus* and investigations for attractants and pheromones

(TN Raviprasad, PS Bhat and KV Nagaraja)

The project aims at standardizing mass rearing technique, to obtain sufficient adult beetles for studies on attractants and pheromones for cashew stem and root borer *Plocaederus ferrugineus* L.

a) Survey for collection of various stages of the pest

Survey was conducted at KCDC plantations, Kunthur, Koila, Alangar and Bajathoor in addition to NRCC campuses at Shantigodu and Kemminje to identify the population dynamics of the pest.

Severely infested trees harboured

many overlapping stages of the pest, while moderately infested trees had a lesser overlapping within the generation.

The grub population was high during the premonsoon and monsoon season (May-September), whereas, during post-monsoon (October-January), pre-pupal and pupal stages were encountered. A drastic reduction occurred in grub population during January-March as adult emergence was found to be high, as evidenced by number of emergence holes on bark. The details of the survey conducted are presented in Table 65.

Table 65. Details of *Plocaederus* spp. grubs collected from various survey locations

Month	NRCC, Shantigodu			NRCC, Kemminje			KCDC, Kunthur		
	L	P	Tr	L	P	Tr	L	P	Tr
Mar '93	22	—	12	—	—	—	34	—	19
Apr	41	—	14	—	—	—	48	—	27
May	49	—	20	2	—	6	52	—	29
Jun	84	—	26	—	—	14	64	—	35
Jul	61	—	31	4	—	3	77	—	30
Aug	76	—	24	6	—	4	94	—	36
Sept	84	—	22	—	—	—	118	—	44
Oct	61	—	22	—	—	4	63	14	35
Nov	32	4	14	3	—	3	40	21	30
Dec	16	10	17	—	—	—	18	19	23
Jan '94	11	22	26	—	—	—	28	24	30
Febr	14	—	24	—	—	—	10	—	25
Mar	40	—	21	—	—	—	34	—	25

L = Larva,

P = Pupa

Tr = No. of trees attacked

The survey revealed that the infestation occurred in patches with a severely affected tree being usually surrounded by a few trees in a moderate stage of attack. However, isolated trees were also found to be severely attacked by the pest. Wide spread presence of *Plocaederus obesus* in large numbers (43.66 per cent) along with the dominant stem borer species, *Plocaederus ferrugineus* was also noticed. The attack of *Batocera rufomaculata* was restricted, only to trees in final stages of attack.

b) Laboratory rearing on host bark

The grubs were collected in polythene covers along with pieces of host bark from the fields and were transferred to labelled rearing bottles containing host bark pieces. Cleaned fibrous frass was added upto one-third of bottle to conserve moisture of the bark and water was sprayed in summer to maintain the softness and edibility of the bark. Water sprayed barks were effective for ten days whereas, the unsprayed needed replacement within six days.

The grubs were reared on matured bark pieces till the emergence of prepupa indicated by the calcareous smearing for cocoon formation. The grubs disturbed

during this stage led to smaller pupa, with high mortality or weak adult beetles. Survival data of host reared grubs is given in Table 66.

Bottles were capped with wire mesh to prevent escape of emerging adult beetles. These adult beetles were transferred for mating and oviposition into one cubic ft. acrylic cage. The average fecundity of female beetle was 72.5 eggs.

Initially, cashew bark pieces were provided to elicit oviposition. As the collection of eggs from crevices is tedious, a novel method of collection by wrapping a cotton tape of 2 cm width onto stout twigs of cashew was undertaken. The females inserted the eggs between the cloth and the bark, which could be easily dislodged with camel hair brush. The total number of eggs laid in the new method (cotton tape wrapped twigs) was higher than that on bark (Table 67) and the same was continued for further oviposition studies.

The collected eggs were labelled and placed in covered petridish, hatched grubs were placed on small pieces of fresh host bark, and monitored for moulting. The

Table 66. Survival of *Plocaederus* spp. reared on host bark

Month	Total No. of grubs	Larval mortality (%)	Prepupal mortality (%)	Pupal mortality (%)	Survival to adulthood
Aug. 93	170	8.82 (15)	11.6 (18)	5.83 (8)	75.88 (129)
Sep.	202	8.90 (18)	12.5 (23)	4.96 (8)	75.74 (153)
Oct.	124	8.06 (10)	11.4 (13)	9.90 (10)	73.38 (91)
Nov.	72	9.27 (7)	13.8 (9)	7.14 (4)	72.22 (52)

Figures in parentheses indicate actual number died at that stage

Table 67. Distribution of eggs of *Plocaederus* spp. during rearing

Date of collection	<i>P. ferrugineus</i>		<i>P. obesus</i>	
	No. of eggs on tape wrapped twigs	No. of eggs laid on bark	No. of eggs on tape wrapped twigs	No. of eggs laid on bark
30-1-94	47 (70.1)	20 (29.9)	36 (75.0)	12 (25.0)
06-2-94	53 (79.1)	14 (20.9)	61 (68.5)	28 (31.5)
09-2-94	46 (63.0)	27 (36.9)	37 (62.7)	22 (37.3)
18-2-94	47 (71.2)	19 (28.8)	47 (69.5)	18 (30.5)
21-2-94	32 (69.6)	14 (30.4)	29 (72.5)	11 (27.5)

Figures in parentheses indicate the percentage egg hatch

second and third instar larvae were transferred onto bigger bark pieces placed in rearing bottles. The body dimensions and body weight were recorded regularly.

c) Rearing on semi-synthetic diet

The grubs of *Plocaederus ferrugineus* were used for evaluating the following diets

- Ground cashew bark + rice flour + SM
- Ground cashew bark + wheat flour + SM
- Ground cashew bark + bengalgram + SM
- Saw dust + rice flour + SM
- Saw dust + wheat flour + SM
- Saw dust + bengal gram flour + SM

SM = supplement mixture

The composition of bark and flours were altered in the ratios from 20:80 to 80:20, while, the composition of supplement mixture was kept constant. Agar agar at 35 per cent was used as the medium stabilizer.

The semi-synthetic diet was prepared by grinding fresh bark and mixing with

specified flour and supplement mixture into melted agar. This was poured for cooling and cut into two inch cubes, which were sterilised in rearing bottles, and provided as feed to the grubs.

The grubs fed on these semi-synthetic media containing host bark without hesitation, while, the grubs showed only bibbling on saw dust based media indicating the presence of feeding stimulators in cashew bark and that its inclusion in diet preparation is essential.

All the diets tested showed fungal growth in ten days. Bengal gram flour based diet was the most acceptable as the keeping quality was good, whereas, rice and wheat flour based diets became soggy with the growth of saprophytic fungi. Three adults of *Plocaederus* spp. could be obtained from this diet within 10 days.

d) Biochemical studies on bark composition

Studies on the biochemical changes in host bark due to grub feeding were studied. The grubs were allowed to feed both on

young and old bark for different periods and after feeding, the dried bark was analysed for sugars, phenols, ortho-dihydroxy phenols and tannins.

Feeding of grubs both on young and old bark resulted in decreased total sugars, phenols and OD phenols. Bark tannin increased subsequent to feeding and so also in the control (Table 68).

Table 68. Effect of *Placaederus ferrugineus* feeding on cashew bark composition

Tissue	Feeding period (weeks)	Total sugars (mg/100mg)		Phenols ($\mu\text{g}/100\text{mg}$)		OD phenols ($\mu\text{g}/100\text{mg}$)		Tannins (mg/100mg)	
		Control	Fed	Control	Fed	Control	Fed	Control	Fed
Young bark (5 yr old)	0	2.50	—	148.0	—	36.3	—	42.9	—
	1	0.66	0.66	42.8	41.0	16.9	15.8	33.6	52.3
	2	2.49	0.62	83.5	69.1	27.4	9.9	62.1	45.2
	3	3.51	0.78	126.8	61.8	41.9	17.3	53.3	40.7
Old bark (10 yr old)	0	1.19	—	110.0	—	31.0	—	17.6	—
	1	2.19	1.56	74.5	52.1	22.4	21.7	28.8	14.7
	2	3.84	0.70	104.4	37.8	36.3	9.0	49.2	12.7
	3	3.60	0.97	152.7	47.2	50.8	11.7	41.2	28.3

QUALITY ANALYSIS AND POST-HARVEST TECHNOLOGY

Attempts have been made to study biochemical changes during storage of nuts and to arrive at a suitable temperature for storage of cashewnuts. The kernel lipid did not change while neutral lipids decreased initially followed by an increase during storage. The kernel protein increased while lysine decreased with maturity. The kernel sugar, lysine and shell CNSL content decreased when bulk nuts are stored beyond 12 months.

Biochem.I : Studies on biochemical changes during storage of cashewnuts and apples

(KV Nagaraja)

This project was started in the year 1990 and had an objective of studying biochemical changes during storage and arriving at a suitable temperature for storage of cashew apples.

Studies on changes in kernel lipids during storage of nuts both at ambient and low temperature were continued. Total lipid during storage did not change appreciably, whereas, neutral lipids decreased initially

Table 69. Lipid changes during storage of cashewnuts

Storage Temp. (°C)	Variety	Storage period (days)	Total lipid %	Neutral lipid	% of total lipid	
					Glyco lipid	Phospho lipid
30	VRI-1	0	53.2	95.0	3.3	1.7
		70	51.8	52.4	44.7	2.9
		280	53.3	81.6	17.5	0.9
		420	47.8	34.9	61.5	3.5
		490	39.1	24.4	71.1	4.4
		560	49.3	97.8	0.9	1.2
		630	46.4	93.4	2.4	4.1
	VRI-2	0	48.6	96.7	2.3	0.9
		70	50.4	90.5	4.2	5.4
		280	47.4	78.2	19.7	2.0
		420	44.1	37.6	59.9	2.4
		490	38.1	30.0	67.3	2.9
		560	42.5	92.9	4.7	2.3
		630	44.2	94.9	2.3	2.7
6	VRI-1	70	56.2	87.1	5.9	6.8
		280	50.6	79.4	19.7	0.9
		420	49.8	46.9	48.7	4.3
		490	37.0	37.2	55.9	7.3
		560	50.1	96.2	1.6	2.1
		630	47.2	94.5	2.1	3.9
		VRI-2	70	52.2	91.8	4.5
	280		50.9	81.2	17.6	1.2
	420		48.4	68.2	28.8	3.0
	490		36.6	51.0	44.2	5.2
	560		44.0	94.5	2.9	2.5
	630		49.4	92.0	3.6	4.4

Table 70. Biochemical changes during development of nuts

Days after anthesis	Protein %	Lysine ($\mu\text{g}/\text{mg}$ protein)	Neutral lipid	Glyco-lipid		Phospho lipid
				% of total lipid		
25	22.6	95.25	64.5	25.9	9.5	
35	41.5	56.06	53.5	36.7	9.9	
45	72.1	44.55	25.5	72.1	2.3	
60	65.2	31.44	54.2	42.8	3.0	

followed by an increase. Results of lipid changes during storage are presented in Table-69.

Biochemical changes during maturity of cashew nuts were investigated and changes in kernel protein, lysine and lipids are presented in Table 70. Kernel protein increased with maturity while lysine

decreased.

Bulk nuts after storing at ambient temperature for different period of intervals were got processed and the kernels were assessed both for processing and biochemical quality. Results are presented in Table-71. Sugars, lysine and shell CNSL content decreased during storage.

Table 71. Biochemical changes during storage of bulk nuts

Constituent	Storage period (months)					
	0	4	8	12	Good	16 Spoiled*
Shelling percentage	27.5	24.8	25.0	28.0	21.5	20.9
CNSL (Shell)	27.9	31.6	33.0	18.1	21.4	—
Lipid %	54.9	53.9	53.0	43.2	46.2	43.9
Protein %	51.0	73.2	70.6	59.8	71.2	67.6
Starch %	33.3	33.3	52.6	37.8	26.8	28.9
Sugars %	8.5	8.6	10.7	7.8	6.1	3.0
Lysine ($\mu\text{g}/\text{mg}$ protein)	68.6	44.4	41.6	40.5	31.8	33.1

* Kernels were of very poor quality with distinct stale smell.

TRANSFER OF TECHNOLOGY

During the year a total of 41,677 cashew grafts were sold with realisation of Rs. 319,168. Successful grafts produced during the year were 46,820. Six training courses on Vegetative Propagation of Cashew (4) and Cashew Production Technology (2) were organised and a total of 97 persons including gardeners, farmers, agricultural officers, students and ARS trainees were trained. A total of Rs. 30,089 was given as subsidy under Central Sector Scheme sponsored by DCD, Cochin to demonstration farmers.

Gen. I : Production of parental materials and breeders' stock of cashew

(KRM Swamy, B Nagaraja and MGangadhara Nayak)

The project was started under Revolving Fund Scheme during 1989 with an objective of taking up commercial multiplication of released cashew varieties and other elite materials for distribution to development agencies and farmers. During the year, 41,677 cashew grafts were sold and a revenue of Rs. 3,19,168 was realised. A total of 46,820 successful grafts of different varieties were also produced during the year. Cashew seeds when stored at low temperature (6°C) retained seed viability for a longer period.

Production of planting materials

Soft wood grafts of released cashew varieties and other elite materials were produced from June 1993 to March 1994. For raising the root stock seedlings, a total number of 81,110 seeds of VTH-174 were sown in polythene bags from May 1993 to November 1993. The germination percentage ranged from 48.0 (November) to

86.2 (May) with a mean of 81.9 (Table 72). During June 1993 to March, 1994, a total number of 64,660 soft wood grafts were prepared, of which 46,820 were successful with a mean of 72.4 per cent (Table 73). A total number of 64,660 scions were

Table 73. Cashew grafts produced during 1993-94

Month of grafting	No. of grafts prepared	Graft success (No.)
Jun.	700	550 (78.5)
Jul.	9,725	7,925 (81.5)
Aug.	10,100	8,180 (80.9)
Sep.	11,605	8,800 (75.8)
Oct.	7,260	5,530 (76.2)
Nov.	6,025	4,050 (67.2)
Dec.	6,110	3,300 (54.0)
Jan.	5,935	4,000 (67.3)
Feb.	3,375	1,840 (54.5)
Mar.	3,825	2,645 (70.1)
Total	64,660	46,820 (72.4)

Figures in parantheses indicate percent graft success

Table 72. Cashew root stock seedlings raised for grafting during 1993

Month of sowing	No. of seeds sown	No. germinated	% germination
May.	23,520	20,285	86.2
Jun.	22,690	19,400	85.5
Jul.	—	—	—
Aug.	11,400	9,500	83.3
Sep.	11,500	9,700	85.0
Oct.	10,700	7,640	71.4
Nov.	3,300	1,600	48.0
Total	83,110 (540kg)	68,125	81.9

collected for grafting in the nursery during the year from the cashew scion bank (located both at Shantigodu and Kemminje)

Studies on cashew seed storage

The germination in cashew seeds gets reduced drastically after November. In order to explore the possibility of retaining the seed viability in cashew, studies on storage of seeds at low temperature (6°C) were carried out from July 1993 to February 1994. Three methods of storage, namely, storage of seeds (a) in gunny bags at room temperature (control); (b) in polythene bags at room temperature and (c) in polythene

bags at low temperature were tried. The stored seeds were sown every month starting from July 1993 upto February 1994 in polythene bags. The germination percentage was recorded after three weeks of sowing. There was a gradual decrease in the germination percentage of seeds in all the three treatments as the storage period increased. The loss of seed viability, however, was more pronounced in the case of seeds stored in gunny bags (control) as compared to other two storage methods. Storage of seeds at low temperature retained the seed viability for longer time (Table 74).

Table 74. Storage of cashew seeds under low temperature (6°C.)

Month of sowing	No. of seeds sown/treatment	Storage treatments		
		Gunny bag	Polythene bag (per cent germination)	6°C
Jul. 1993	100	86	88	85
Aug. 1993	100	80	85	85
Sep. 1993	100	82	85	85
Oct. 1993	100	70	80	80
Nov. 1993	100	51	70	74
Dec. 1993	100	25	47	53
Jan. 1994	200	25	40	60
Feb. 1994	300	25	46	60

Extn. I : Training extension and research workers and farmers

(Sreenath Dixit and KRM Swamy)

This project has an objective of establishing the link between research and extension personnel of the development departments and farmers, by organizing training courses on various aspects of cashew production technology.

During the year four training courses on vegetative propagation of cashew were conducted. A total of 56 trainees including gardeners, farmers and agricultural officers from the States of Karnataka (44) and

Madhya Pradesh (12) attended the training courses. Two courses on Cashew Production Technology were conducted and officials from Cashew/Forest Development Corporations and Department of Horticulture/Agriculture attended the courses. The trainees were from Andhra Pradesh (7); Goa (2); Karnataka (20); Kerala (1); Tamil Nadu (6) and West Bengal (1). Besides, four ARS scientists undergoing subject matter training at CPCRI, Kasaragod, also attended the training course (Table 75).

Table 75. Details of training courses conducted

Course Title	Date	No. of participants
Vegetative Propagation of Cashew	10-12 Aug. 1993	5
	13-15 Aug. 1993	7
	17-18 Sep. 1993	19
	20-21 Sep. 1993	25
	Total	56
Cashew Production Technology	04-06 Jan. 1994	12
	08-10 Feb. 1994	29*
	Total	41

* Includes 4 ARS trainees from CPCRI., Kasaragod.

Extn IV : Research-cum-Demonstration plots

(Sreenath Dixit and PS Bhat)

This project aims at disseminating the new technologies of cashew production developed at Research Centre to farmers by laying out demonstrations on farmers' fields.

Fifty demonstration plots (0.4-0.8 ha) have been laid out on farmers' fields in the taluks of Puttur, Buntwal, Sullia and Belthangady of Dakshina Kannada between 1988 and 1993. This project is sponsored by the Directorate of Cashewnut Development (DCD), Cochin, under Central Sector Scheme. Of the 50 plots, 38 have been established by NRCC and 12 by Sreeksheeta Dharmasthala Rural Development Project (SKDRDP), Dharmasthala (Table 76). Due to unsatisfactory performance or non-compliance to carry out the recommended practices of cashew cultivation, eight plots (seven of those established by NRCC and one by SKDRDP) have been dropped from the Scheme at various stages. All the plots

were monitored during the year under report. The amount of subsidy disbursed under the Central Sector Scheme of the DCD is given in Table 77.

A meeting of the newly selected demonstration farmers was held on 26th June for explaining their role in spreading improved cashew production technology.

Table 77. Subsidy given to demonstration farmers under Central Sector Scheme sponsored by the Directorate of Cashewnut Development, Cochin, from 1988-1994

Year	Amount of subsidy (Rs.)
1988-89	12,311
1989-90	20,624
1990-91	28,169
1991-92	24,554
1992-93	23,720
1993-94	30,089
Total	1,39,467

Table 76. Cashew demonstration plots established during 1988-93 in Dakshina Kannada

Year	NRCC			SKDRDP			Net Total
	Established	Dropped	Total	Established	Dropped	Total	
1988*	20	05	15	—	—	—	15
1989	09	02	07	07	01	06	13
1990	—	—	—	05	—	05	05
1993	09	—	09	—	—	—	09
Total	38	07	31	12	01	11	42

* Plots established during 1988 cease to get subsidy as they have completed five years.

Extn. V: Communication behaviour and socio-economic characteristics of cashew demonstration farmers - A study in Dakshina Kannada

(Sreenath Dixit)

Studies have been initiated to analyse the communication behaviour and socio-economic characteristics of demonstration farmers. Suitable sample size and other statistical requirements were arrived at after reviewing the socio economic studies conducted at CPCRI, Kasaragod and discussion with Economists and Statisticians.

Further, a preliminary attempt was

made to classify the performance of all the demonstration farmers who have completed five years of association with NRCC. The items considered for determining the performance were soil fertility, gradient, general maintenance of the plots, response to guidance and yield. The distribution of demonstration farmers in different performance categories is given in Table -78.

Table 78. Distribution of demonstration farmers in performance categories

Category	Number	Percent
Very good	01	02.78
Good	16	44.44
Average	14	38.89
Poor	05	13.89
Total	36	100.00

Adhoc Scheme : Screening and Biochemical evaluation of Cashew germplasm in relation to tea mosquito infestation (1988-1993).

K.V. Nagaraja, D.Sundararaju, Joy N John (Nov. 1988-Feb. 1992), P.S. Bhavanishankara Gowda (Apr 1989 - Oct. 89)
K. Prasanna Rai (April 1990 - July 90) and Venugopalakrishna Kurup (Mar 1992 - May 93).

Objectives

1. To screen cashew accessions for tea mosquito tolerance.
2. Comparative biochemistry of susceptible and tolerant cashew accessions.
3. To study biochemical changes in susceptible accession due to infestation.
4. Extraction and characterization of saliva from tea mosquito.
5. To study biochemical changes due to infestation in alternate hosts.
6. Enzymatic changes in susceptible accessions due to infestation.

Materials and Methods

Cashew accessions in the germplasm both at Shanthigodu and Kemminje were used for entomological and biochemical studies. Screening the cashew germplasm for tea mosquito tolerance was undertaken under laboratory conditions and a laboratory screening technique was developed. As a prerequisite for laboratory screening, mass rearing technique for tea mosquito was standardised. Biochemical investigations were carried out both on healthy and infested plant tissue at different period of infestation. Various biochemical con-

stituents and enzymes were estimated as per methods reported earlier.

Results and Discussion

Biochemical studies Changes in biochemical constituents induced by tea mosquito infestation in an accession susceptible to tea mosquito (VTH 174) were studied and the results are presented in Table 1. For these studies forty day old cashew seedlings were infested with 5 day old nymphs for different period of intervals. After infestation, the seedlings were graded and the infested tissue was used for biochemical analysis. Sugars and amino acid contents both in leaf and shoot decreased with increased period of infestation. Concentration of proline, total phenols, orthodihydroxy phenols and organic acids increased after 24 hr of infestation followed by a decrease. Changes in the leaf starch content during infestation were, however, not significant.

Changes in chlorophyll and carotenoid pigments in leaf during infestation by tea mosquito were studied (Table 2). Significant changes in chlorophyll a and carotenoid pigments were observed during infestation. Ratio of chlorophyll a to b decreased during infestation.

Table 1. Changes in biochemical constituents of cashew during infestation by tea mosquito

Tissue	Period of infestation (hr)	Sugars (mg/g)	Aminoacids (mg/g)	Proline (ug/g)	Phenols (mg/g)	Orthodihydroxy phenols (mg/g)	Organic acids (mg/100 mg)	Starch (mg/g)
Leaf	0	7.65	0.307	125.80	0.363	0.153	15.81	41.34
	24	5.81	0.251	134.65	0.716	0.289	28.26	85.87
	72	3.19	0.182	57.37	0.500	0.203	28.21	39.36
	120	2.40	0.164	38.20	0.588	0.210	11.69	34.80
Shoot	0	5.24	0.358	44.32	0.141	0.079	21.14	
	24	4.81	0.302	122.77	0.304	0.208	30.38	
	72	2.22	0.107	24.39	0.119	0.074	32.01	
	120	1.22	0.108	35.72	0.105	0.040	36.97	
Leaf	CD	3.0**	NS	NS	0.280*	NS	NS	NS
Shoot	CD	2.43**	0.154**	69.54*	0.128*	0.084**	NS	

** Significant at P = 0.01 * Significant at P = 0.05

Values expressed on fresh weight basis and are mean of four individual estimations

Table 2. Changes in chlorophyll and carotenoid pigments of cashew during infestation by tea mosquito

Period of infestation (hr)	Chl a (µg/mg)	Chl b (µg/mg)	Chl a+b (µg/mg)	a/b	Carotenoids (µg/g)
0	0.333	0.155	0.487	2.15	0.082
24	0.233	0.198	0.430	1.18	0.051
72	0.408	0.101	0.513	4.04	0.142
120	0.267	0.222	0.468	1.20	0.058
CD	0.108 *	NS	NS		0.03 **

* Significant at P = 0.05 ** Significant at P = 0.01

Values expressed on fresh weight and are mean of four individual estimations.

Changes in the activities of acid phosphatase, superoxide dismutase, phenylalanine ammonia lyase and nitrate reductase during infestation by tea mosquito were studied and the results indicated that activity of superoxide dismutase

decreased during infestation. Activities of acid phosphatase, phenylalanine ammonia lyase and nitrate reductase, did not change significantly during infestation by tea mosquito (Table 3).

Table 3. Changes in the activities of enzymes of cashew during infestation by tea mosquito

Tissue	Period of infestation (hr)	Acid phosphatase	Superoxide dismutase	Phenyl alanine ammonia lyase	Nitrate reductase
Leaf	0	17.98	0.288	1.212	18.586
	24	2.22	0.087	2.734	24.686
	72	1.33	0.168	1.138	18.830
	120	23.17	0.100	1.823	13.278
Shoot	0	15.26	0.189	2.883	14.717
	24	12.93	0.234	3.794	21.189
	72	1.77	0.099	5.175	17.353
	120	4.21	0.106	5.229	22.451
Leaf	CD	NS	0.128 *	NS	NS
Shoot	CD	NS	0.048**	NS	4.321**

* Significant at P=0.05 ** Significant at P=0.01

Values are mean of four individual estimations.

Acid phosphatase - Pico moles of PNP liberated/min/ μ g protein, Superoxide dismutase - Units/15 min/ μ g protein.

Phenylalanine ammonia lyase - Pico moles t-cinnamic acid formed/min/ μ g protein

Nitrate reductase-Pico moles NO_2 formed/min/mg fresh weight

In order to study biochemical changes during shorter period of infestation, changes were followed at 6 hourly intervals upto 24 hr, and the results are presented in Table 4. All the biochemical constituents analysed either decreased or increased as early as 6 hr after infestation. Sugars content both in leaf and shoot decreased after 6 hr of infestation by tea mosquito. Phenols, orthodihydroxy phenols and starch increased during infestation. Lipid peroxides and lignin increased in leaf and shoot after 6 hr of infestation by tea mosquito.

Leaf lipids were studied during infestation by tea mosquito and the results are presented in Table 5. The total lipid

concentration increased upto 12 hr of infestation followed by a decrease. Neutral lipids increased while, glyco and phospho lipid decreased after 6 hr of infestation.

Neutral and glycolipids from healthy and infested leaf (6 hr) were further fractionated and the results are presented in Table 6. The composition of glycolipid was not affected by infestation. Neutral lipids both from healthy and infested leaf were rich in monoglycerides. Sterol esters, monoglycerides, and triglycerides decreased during infestation. An increase in the hydrocarbon fraction was noticed in the infested leaf.

Table 4. Changes in biochemical constituents during shorter period of infestation by tea mosquito

Tissue	Period of infestation (hr)	Sugars (mg/g)	Aminoacids (ug/g)	Phenols (mg/g)	Orthodihydroxy phenols (mg/g)	RNA (mg/g)	DNA (mg/g)	Starch (mg/g)	Lipid Peroxides	Lignin ($\Delta A_{350}/g$)
Leaf	0	12.23	58.70	1.113	0.305	1.56	1.66	21.67	4.37	—
	6	10.16	144.31	1.184	0.197	3.42	6.30	30.82	7.30	—
	12	5.89	88.12	0.846	0.186	2.42	7.28	22.69	12.06	—
	18	4.42	87.69	0.805	0.241	2.62	3.58	17.49	12.58	—
	24	6.43	145.71	2.024	0.434	2.45	5.78	18.68	23.05	—
Shoot	0	7.88	28.30	0.151	0.035	6.65	0.46	—	3.58	9.90
	6	5.38	38.83	0.241	0.048	7.56	0.55	—	4.03	11.40
	12	3.91	39.19	0.188	0.054	7.78	1.07	—	1.64	13.40
	18	3.94	—	0.161	0.078	4.74	0.92	—	2.09	10.40
	24	5.27	50.56	0.385	0.138	5.30	0.36	—	2.12	10.90
Leaf	CD	3.45**	NS	0.627*	0.132**	NS	NS	8.41*		
Shoot	CD	2.62**	NS	0.102**	0.042**	NS	NS			

** Significant at P = 0.01 * Significant at P = 0.05

Values expressed on fresh weight basis and are mean of four individual estimations

Expressed as n moles MDA/g fresh weight (lipid peroxides).

Table 5. Changes in leaf lipids of cashew during infestation

Period of infestation (hr)	Total lipids (mg/g fr.wt.)	Neutral lipids	Glyco lipids % of total lipid	Phospho lipids
0	10.6	43.4	40.9	15.6
6	60.2	50.3	37.5	12.2
12	62.3	43.4	33.5	23.1
18	21.4	—	—	—
24	10.9	45.3	45.1	9.6

Electrolyte leaching was studied both in healthy and infested leaf tissue and the results are presented in Table - 7. Infestation resulted in increased leaching of small molecular weight components. The con-

centration of sugars in the leachate decreased while that of total phenols and orthodihydroxy phenols increased during infestation by tea mosquito.

Table 6. Composition of neutral and glyco lipids of healthy and infested cashew leaf by tea mosquito

Lipids	Composition	Healthy	Infested
		% of total	
Neutral lipid	Hydrocarbons	8.1	23.5
	Sterol Esters	10.4	5.9
	Trigly cerides	13.6	12.0
	Free sterols	14.5	15.2
	Diglycerides	15.4	14.2
	Monoglycerides	37.9	29.1
Glyo lipid	Acyl sterol glycoside	32.8	35.3
	Monogalactosyl diglyceride	20.2	20.6
	Sterol glycoside	24.6	23.9
	Digalactosyl diglyceride	22.4	20.1

Values are mean of three individual estimations.

Table 7. Changes in leaf leaching and its composition during infestation by tea mosquito

Period of infestation (hr)	Specific conductance (μ Mhos/30 min)	Sugars (mg/g)	Phenols (μ g/g)	Ortho dihydroxy phenols (μ g/g)
0	137.55	1.08	60.74	15.27
6	406.68	1.92	138.41	40.74
12	270.06	0.93	171.30	57.88
18	860.47	1.76	95.48	49.35
24	383.14	1.06	106.09	29.05
72	552.40	0.63	60.98	29.82
120	1097.55	0.54	67.23	22.05
CD	620.79 *	0.824 *	77.20 *	24.85 *

* Significant at P=0.05

Values expressed on fresh weight basis and are mean of four individual estimations

Biochemical changes induced by tea mosquito in alternate hosts such as cotton, neem and henna were studied and the results are presented in Tables 8 and 9. Infestation of leaf by tea mosquito resulted in increased sugars, starch and total phenols contents

(Table 8). Changes in leaf orthodihydroxy phenols contents were, however, not significant. Changes in sugars, phenols and orthodihydroxy phenols in the shoot, were not significant. Lignin content in the shoot increased during infestation (Table 9).

Table 8. Biochemical changes in leaf of alternate hosts during infestation by tea mosquito

Host	Period of infestation (hr)	Sugars (mg/g)	Starch (mg/g)	Phenols (mg/g)	Orthodihydroxy phenols (mg/g)
Neem	0	28.59	48.74	1.36	0.635
	6	123.40	74.00	3.71	1.318
	12	202.19	90.86	3.04	1.245
	18	124.20	47.80	2.17	0.629
	24	56.95	45.10	1.42	0.567
	CD	76.72 *	25.63 *	NS	NS
Henna	0	15.32	9.70	0.841	0.215
	6	19.78	16.31	0.989	0.285
	12	19.76	17.13	1.000	0.270
	18	7.78	20.03	1.816	0.419
	24	14.73	19.15	1.641	0.412
	CD	NS	3.62**	0.87*	NS
Cotton	0	15.16	39.82	2.80	2.48
	6	43.10	94.18	1.65	1.81
	12	31.74	62.17	0.68	0.87
	18	16.28	58.72	0.63	0.71
	24	37.84	77.85	1.41	1.05
	CD	14.48**	29.85 *	1.08**	NS

Values expressed on fresh weight basis and are mean of three individual estimations.

* Significant at P=0.05 ** Significant at P=0.01

Table 9. Biochemical changes in the shoot of alternate hosts during infestation by tea mosquito.

Host	Period of infestation (hr)	Sugars (mg/g)	Lignin (ΔA 350/g)	Phenols (mg/g)	Orthodihydroxy phenols (mg/g)
Neem	0	5.43	11.55	0.533	0.225
	6	4.62	25.55	0.804	0.326
	12	3.11	17.63	0.251	0.073
	18	3.20	18.67	0.516	0.173
	24	3.73	16.04	0.580	0.198
	CD	NS	NS	NS	NS
Henna	0	10.08	9.21	0.293	—
	6	11.94	12.54	0.419	—
	12	17.95	9.96	0.399	—
	18	38.58	9.00	1.440	—
	24	21.53	9.39	0.715	—
	CD	8.75 *	—	0.72 *	—
Cotton	0	12.93	3.20	0.175	0.057
	6	7.73	8.02	0.318	0.191
	12	14.43	11.43	0.266	0.154
	18	5.29	9.99	0.514	0.280
	24	5.51	8.27	0.262	0.184
	CD	NS	—	NS	NS

Values expressed on fresh weight basis and are mean of three individual estimations

* Significant at P=0.05

Tender shoots of accessions identified earlier as moderately susceptible by laboratory screening were analysed for total phenols and orthodihydroxy phenols and the results are presented in Table 10.

Table 10. Analysis of tender shoots from moderately susceptible accessions.

Variety	Total phenol (μ g/g fr.wt.)	Orthodihydroxy phenols (μ g/g fr.wt.)
BPP-2	0.273	57.64
V-1	0.309	133.86
NRCC Sel.1 (VTH 107/3-1)	0.173	49.01
BPP-3	0.362	62.21
V-3	0.685	147.93
G 11/6	0.617	106.65
H 24/7	0.272	46.0
H 28/1	0.305	52.0
H 32/6	0.229	25.6
VTH 153/1	0.310	69.0

Mean of three individual estimations

Table 11. Biochemical changes during infestation (24 hr) by tea mosquito in moderately susceptible and susceptible accessions.

Accession	Tissue		Sugars (mg/g)	Starch (mg/g)	Phenol (mg/g)	OD phenols (mg/g)
VTH 153/1	Leaf	Control	5.73	13.74	0.797	0.249
		Infested	7.94	13.23	0.919	0.29
	Shoot	Control	5.69		0.310	0.069
		Infested	3.51		0.232	0.070
R_2	Leaf	Control	3.85	7.93	1.059	0.262
		Infested	5.57	17.25	0.660	0.237
	Shoot	Control	4.94		0.207	0.071
		Infested	3.92		0.337	0.095

However, on subsequent screening, all the accessions except VTH 153/1 exhibited susceptible reaction towards tea mosquito. Total phenols and orthodihydroxy phenols contents did not seem to reflect on the susceptibility of the accession.

Biochemical changes during infestation by tea mosquito (24 hr) of a moderately susceptible accession (VTH 153/1) and a susceptible check (R_2) were studied and the results are presented in Table 11. Sugar content during infestation increased in leaf and decreased in shoot both in moderately susceptible and susceptible accession. Total phenols orthodihydroxy phenols content in the leaf increased in moderately susceptible accession and decreased in susceptible accession during infestation by tea mosquito. Leaf starch content in the moderately susceptible accession did not change while it increased in susceptible accession. Thus accessions appear to exhibit different response with respect of leaf phenols and starch during infestation.

Entomological Studies

A method was standardised for mass culturing of tea mosquito for laboratory screening of accessions. The shoots with eggs (10-20) were kept with potted seedling covered with cylindrical polythene film cage (30 x 75 cm). The newly hatched nymphs were allowed to feed for two days on potted cashew seedling, supplemented with two tender cashew shoots. On the third day, the nymphs were transferred to aluminium cage (15-20 nymphs/cage) and reared. The number of nymphs reared during last five years are presented in Table 12. In all the years, least mortality of nymphs was observed in the month of January.

A technique for laboratory screening of cashew accessions for tea mosquito tolerance was standardised. The damage score for accessions screened is presented in Tables 13 to 15. Based on these observations, H 24/7, H 28/1, H 32/6, Goa 11/6 and VTH 153/1 were identified as

moderately susceptible accessions. However, in subsequent screening, all the accessions except VTH 153/1, exhibited susceptible reaction (Table 16).

Culturing of tea mosquito on alternate hosts such as henna, neem and cotton was attempted and the results are presented in Table 17. The percentage mortality on henna was comparable with cashew. However, in one of the experiments, the mortality on henna was quite high.

Feeding behaviour at different phenological stages of the tissues in accessions differing in response to tea mosquito was studied and the results are presented in Table 18. Results have indicated that the grafts having matured shoot recorded least damage as well as oviposition. Tender shoots were most vulnerable for the damage by tea mosquito. Green shoots were preferred tissue for oviposition.

Table 12. Mass culturing of tea mosquito

Month	% Mortality observed				
	1989	1990	1991	1992	1993
Jan		7.8	8.7	18.4	23.1
Feb		—	—	19.6	31.4
Mar		24.7	6.1	34.1	35.9
Apr		16.0	24.5	—	33.8
May		29.5	18.1	—	
Jun		—	13.2	30.5	
Jul	25.1	44.4	30.0	28.1	
Aug	22.9	8.2	6.5	32.2	
Sep	24.3	21.4	13.2	29.8	
Oct	20.0	10.1	12.0	36.6	
Nov.	10.0	10.5	16.0	29.5	
Dec.	9.6	13.4	17.0	27.0	

Table 13. Laboratory screening of cashew variety/accessions for resistance to tea mosquito bug by preference feeding method (two fourth instar nymphs grafts - feeding period 48 hr).

Accession No.	Shoot damage Score (0-4 scale)	Mid rib damage score (0-9 scale)	Damage on lamina (0-9 scale)
Vengurla 1	3.0	4.4	2.7
2	4.0	5.8	1.9
3	2.5	3.8	2.0
4	3.8	4.5	1.7
5	3.8	5.7	3.3
Bapatla 1	3.3	3.9	2.1
2	2.8	3.7	2.8
3	2.8	2.8	1.7
4	3.5	4.8	2.0
Ulla-1	3.5	4.0	2.9
Bla 139-1	4.0	7.0	3.8
VRI-1	3.8	5.4	3.3
VRI-2	3.8	5.2	2.1
VTH 107/3	3.0	4.2	1.6
M 45/4	3.3	5.7	2.1
M 68/1	3.0	3.9	1.8
M 26/2	3.3	5.0	3.7
M 33/3	3.8	4.0	2.2
Kunthur-24	3.5	4.5	2.1
Susceptible check	3.5	3.5	2.0

	Shoot damage score	Midrib damage score
Resistant	0-1	0-1
Moderately resistant	1.1-2.0	2-3
Moderately susceptible	2.1-3.0	4.6
Susceptible	3.1-4	7-8

Table 14. Laboratory screening of cashew accessions to tea mosquito bug (preferential feeding method)

Accession	No. of grafts screened	No. of grafts scored highest damage on		Mean damage score scale (0-4)
		Shoot	Leaf	
<u>Released and pre-release accessions</u>				
V-1	13	10	3	3.44
V-3	10	6	4	3.90
BPP-2	10	10	—	3.90
BPP-3	10	6	4	3.33
BPP-5	10	7	3	3.44
VTH 3/4	11	10	1	3.90
VTH 36/3	10	5	5	3.38
VTH 107/3	10	6	4	3.30
VTH 139/4	11	6	5	3.15
VTH 146/1	10	5	5	3.20
VTH 762/4	10	8	2	3.50
<u>Tolerant accessions located at Vittal germplasm</u>				
VTH 151/1	5	—	5	3.80
VTH 151/2	10	7	3	3.21
VTH 151/3	11	3	8	3.83
VTH 151/4	10	7	3	3.90
VTH 152/2	2	—	2	3.50
VTH 152/3	10	4	6	3.56
VTH 152/4	10	4	6	3.55
VTH 153/1	12	11	1	2.92
VTH 153/2	10	7	3	3.35
VTH 153/3	10	5	5	3.85
VTH 153/4	10	9	1	3.60
VTH 54/4	13	9	4	3.21
<u>Tolerant accessions located at hot spot areas</u>				
G 2/5	10	9	1	3.70
G 9	5	2	3	3.45
G 11/6	13	8	5	2.73
G 12	13	4	9	3.28
G 14/7	12	6	6	3.46
G 16	12	6	6	3.42
G 17	10	2	8	3.25
E-1	15	10	5	3.32
E-3	10	10	—	3.60
E-4	10	8	2	3.40
E-5	10	8	2	3.43
Susceptible check	58	42	16	3.60
Kunthur-24	58	32	26	3.45
Resistant	0.0 - 1.0	Moderately susceptible		2.1 - 3.0
Moderately resistant	1.1 - 2.0	Susceptible		3.1 - 4.0

Table 15. Laboratory screening of cashew accessions to *Helopeltis antonii*.

Accession No.	Mean highest damage score	Mean highest damage score on checks		
		Tolerant checks		Susceptible checks
		VTH 153/1	G 11/6	
Released And Pre-Release Accessions				
NDR 2-1	3.38	3.58	3.25	3.69
K 22-1	3.65	3.70	3.53	3.85
BLA 39-4	3.40	2.80	3.23	3.60
VTH 30/4	3.30	3.18	3.02	3.46
NRCC Sel. 2	3.10	3.43	3.33	3.80
Ullal-2	3.53	3.38	3.25	3.70
BPP-6	3.28	2.73	3.13	3.40
VTH-35	3.38	3.30	3.05	3.40
Field Tolerant Hybrids				
H 1/14	3.46	3.07	3.46	3.60
H 2/13	3.10	2.90	3.30	3.20
H 3/18	3.88	3.16	3.19	3.63
H 6/14	3.69	3.21	3.35	3.35
H 7/14	3.17	3.37	3.39	3.33
H 11/14	3.40	3.40	3.44	3.10
H 13/18	3.21	3.28	3.53	3.67
H 15/4	3.18	3.25	3.00	3.13
H 19/3	3.40	2.93	3.20	3.60
H 20/5	3.45	3.05	3.37	3.36
H 24/7@	3.00	3.23	3.00	3.10
H 27/2	3.68	3.75	3.79	3.73
H 28/1@	2.97	2.75	2.98	3.33
H 29/3	3.62	3.40	3.53	3.85
H 30/4	3.40	3.10	3.58	3.70
H 31/5	3.38	3.31	3.24	3.47
H 32/6@	2.79	3.07	3.50	2.93
H 33/2	3.13	3.10	3.40	3.20

Resistant 0-1.0

Moderately resistant 1.1 - 2.0

Moderately susceptible 2.1 - 3.0

Susceptible 3.1 - 4.0

@ Moderately susceptible

Table 16. Screening of moderately susceptible accessions identified earlier against tea mosquito.

Accession	Mean highest damage score (0-4 scale)
H 24/7	3.3
H 28/1	3.2
H 32/6	3.6
Kunthur 24	3.4
G 11/6	3.2
VTH 153/1	2.9
Susceptible check	3.4

0 - 1.0 Resistant
1.1 - 2.0 Moderately resistant
2.1 - 3.0 Moderately susceptible

Table 17. Culturing of tea mosquito on alternate hosts.

Host	No. of Nymphs reared	Mortality (%)
Experiment 1		
Cashew	60	6.0
Henna	45	58.0
Neem	45	91.1
Experiment 2		
Cashew	75	9.3
Henna	45	8.9
Experiment 3		
Cashew	38	20.0
Cotton	41	34.1

Table 18. Effect of phenological stage of cashew on damage and oviposition preference of TMB.

Accession	Damage on								No. of eggs laid			
	Shoot				Leaf							
	M	JF	TS	GS	M	JF	TS	GS	M	JF	TS	GS
VTH 153/1	1.5	4.0	3.0	2.5	0.9	3.6	1.5	0.3	1.0	3.2	5.0	7.5
G 11/6	0.3	3.8	3.8	2.8	—	3.8	3.6	1.3	0.7	2.0	6.0	7.8
H 24/7	0.7	3.7	3.7	2.8	0.1	2.8	3.3	1.2	1.7	9.7	8.5	8.2
H 28/1	0.3	2.8	3.7	2.7	0.2	2.5	3.3	1.2	1.2	4.3	8.0	9.0
H 32/6	0.5	3.7	3.8	3.3	0.2	3.2	3.6	1.9	0.5	5.0	8.0	10.7
Kunthur-24	0.3	3.7	3.3	2.8	0.2	3.9	2.4	1.0	1.7	7.8	8.3	3.0
Susceptible check	0.5	3.5	3.8	3.2	—	3.5	3.5	2.5	2.0	2.0	5.8	6.2

M-Matured shoot, JF-Just Flushing, TS-Tender shoot, GS-Green shoot.

Studies on ovipositional preference on healthy and already damaged grafts were conducted and the results are presented in Table 19. Results indicated that even the damaged green shoots of the grafts, served as host. Thus, this may have influence on population build up under field condition.

Studies on survival of nymphs of tea mosquito on healthy and already damaged green shoots were conducted and the results are presented in Table 20. Even damaged green shoot did serve as host for the tea mosquito.

Table 19. Studies on ovipositional preference on fresh and already damaged grafts of tolerant accession (G11/6)

Damage and number of eggs layed		Fresh grafts	Already damaged grafts
<u>Mean Damage (0-4 Scale)</u>			
Shoot		3.0	3.0
Leaf	Petiole & Midrib	1.5	1.6
	Lamina	0.8	1.4
<u>Mean no. of eggs layed/graft</u>			
Shoot			
	Previous season's growth	2.9	0.7
	Current season's growth	1.9	2.9
	Tender shoots	1.6	1.9
<u>Matured leaf</u>			
	Petiole	1.6	0.3
	Midrib	—	—
<u>Tender leaf</u>			
	Petiole	3.3	1.7
	Midrib	7.4	1.0
Total no. of eggs laid/graft		18.7	8.5
Percentage		68.8	31.2

Table 20. Survival of TMB nymphs on fresh and already damaged shoots of tolerant accession (G 11/6)

Tissue	No. of nymphs reared	% of nymphs reaching adult stage	Sex ratio Female : Male
Fresh shoot	107 (1st instar)	81.3	1:0.9
Damaged shoot	82 (3rd to 5th instar)	74.4	1:1.6

In order to find out the potential of tea mosquito in a particular phenological stage a pair of adults were caged for 48 hr on single graft. After infestation the number of eggs laid, damage and survival

pattern were recorded and the results are presented in Table 21. Results indicated that ovipositional potential and survival pattern on matured shoot were least.

Table 21. Damage, ovipositional potential and survival of adults at different phenological stages of cashew.

Accession	Phenological stage	Damage (0-4 scale)		No. of eggs laid/graft	Plant parts in which oviposited	Survival of adult/graft	
		Shoot	Leaf			No. released	No. survived
G 11/6	Tender shoot	3.5	1.5	13.2	Midrib, petiole and shoot	2.0	2.0
	Matured shoot of cropping season	0.8	0.6	3.8	petiole and shoot	2.0	1.3
	Matured shoot of rainy season	0.9	0.9	1.8	petiole and shoot	2.0	1.9
Kunthur 24	Tender shoot	3.0	1.6	14.7	Midrib, petiole and shoot	2.0	2.0
	Green shoot	3.0	1.0	11.4	Midrib, petiole and shoot	2.0	2.0
	Matured shoot	1.0	0.3	3.0	Petiole and shoot	2.0	1.2
Susceptible check	Tender shoot	3.3	2.2	15.5	Midrib, petiole and shoot	2.0	2.0
	Green shoot	3.0	1.5	13.7	Midrib, petiole and shoot	2.0	2.0
	Matured shoot	1.3	0.8	5.2	Petiole	2.0	1.5

Conclusions

Mass rearing technique for tea mosquito was standardised. Henna and cotton also could be used as hosts for rearing tea mosquito. Laboratory screening technique for tea mosquito tolerance was standardised. Among the accessions screened for tea mosquito tolerance, VTH 153/1 has shown to exhibit moderately susceptible reaction. Tender shoots were most preferred for feeding by tea mosquito. Damaged green shoots also served as host for tea mosquito.

Biochemical studies revealed that infestation of cashew by tea mosquito resulted in decreased sugars, Chl a and carotenoid pigments. Total phenols, orthodihydroxy phenols, starch and lignin increased during infestation. Infestation resulted in increased leaching of small molecular weight compounds. Studies on shorter period of infestation indicated that biochemical changes are manifested as early as 6 hr after infestation. Results from biochemical changes in alternate hosts such as cotton, neem and henna after infestation by tea mosquito indicated that the hosts exhibit differences with respect to response of some of the biochemical constituents. Total phenols and orthodihydroxy phenols in the shoots of moderately susceptible

accession were estimated. Biochemical changes induced by tea mosquito infestation in susceptible and moderately susceptible accessions were studied and the results indicated that the response of leaf phenols and starch is different in susceptible and moderately susceptible accession.

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2. Sundararaju D. and John Joy N., 1993, Susceptibility of cashew accessions to *Helopeltis antonii* sign (Heteroptera:-Miridae) in the preflowering phase. *J. Plantation Crops* **21**:50-53.
3. Nagaraja K.V., Bhavanishankara Gowda P.S., Venugopalakrishna Kurup V. and John Joy N., 1994, Biochemical changes in cashew in relation to infestation by tea mosquito. *Plant Physiology and Biochemistry*, In Press.

Hort. II (a) : Demonstration of beneficial effects of pruning in cashew.

E. Mohan (1988-90);

M. Gangadhara Nayak (1990-1994)

Objective

To demonstrate the beneficial effects of pruning in cashew on a large scale.

Materials and Methods

The trial was initiated in the concluded NPK fertilizer trial at Experimental Station, Shanthigodu, during the year 1988-89. The plants selected for imposing treatments were of the seedling progeny of variety VTH-174 planted during the year 1976 for NPK fertilizer trial. Sixty border trees receiving uniform treatments were used for imposing pruning treatment. The yield data for three years was collected for selected trees and the mean was calculated. Among the selected 60 trees, 30 were utilised for imposing pruning treatment and the remaining 30 served as control. Initially dead wood and dry twigs were removed with the help of sickle and the larger dried limbs if any, were removed with the help of saw.

The leader shoots of pencil thickness which had not turned into ash colour were selected for pruning. About 60 per cent of total leader shoots were pruned to 1/3 rd of the original length with the help of a secateur. Along with this operation criss-cross branches spreading on the ground and watershoots were also removed. Larger cut wounds were treated with the Bordeaux paste (10%) and a spray of 1 percent Bordeaux paste (10%) was given to prevent the entry of fungal pathogens

if any, through the cut wounds of leader shoots.

The treatments were imposed between 2nd week of July and end of August and the operations were continued for five years.

After collecting yield data, the mean was calculated. The quantity of pruned, both dead and the live wood was recorded separately. To confirm the results of pruning an onfarm trial was initiated in KCDC plantations at kunthur. Sixty trees were used for pruning treatments and 60 trees served as control. The trial was carried out for two years.

Results and discussion

Before imposing pruning treatment, the mean yield data for pruned trees was 3.65 kg while, that of unpruned trees was 3.08 kg (Table 1). In the very first harvest after imposing pruning treatment it was more than double over the control and also more than that of average of previous three harvests. In the subsequent harvests also, the yield in pruned trees was higher over control. In the control plot where the pruning was not done the yield declined (Table 2).

The quantity of the wood removed, either live or dead had no correlation with the nut yield.

On farm trial

Before initiating the trial mean yield of selected 60 trees for pruning was 1.70 kg/tree and it was 2.00 kg in the case of control plants. The yield increased by more than two folds as compared to previous years and the control. Even in the subsequent harvests the pruned trees continued to yield higher than that of control (Table 2.).

Economics

The only additional cost involved for imposing pruning treatment is the cost of labour and Bordeaux mixture which worked out to be Rs. 8.12 per tree per year. Compared to the increased yield realised the cost involved in pruning is less.

Conclusions

In old and unthrifty plantations, the leader shoot pruning is helpful in enhanc-

ing the nut yield. The additional yield obtained by pruning compensates the extra cost involved in pruning. Thus, at least once in 2-3 years removal of dead wood and leader shoot pruning can be practiced in old and unthrifty plantations.

Table 1. Mean yield (kg/tree) of pruned and unpruned trees.

	Yield (Kg/tree)	
	Pruned	Unpruned
Three years mean before imposing pruning treatment	3.65	3.08
After imposing pruning treatment		
1988-89	5.88	2.61
1989-90	2.32	1.17
1990-91	3.93	1.36
1991-92	2.19	1.23
1992-93	2.34	1.17
Cumulative mean	3.53	1.51

Table 2. Mean yield of pruned and unpruned trees in "On Farm Trial".

Treatment	Yield (kg)			Mean (kg)
	Before pruning (1991-92)	After pruning		
		1992-93	1993-94	
Unpruned	2.06	3.16	1.66	2.41
Pruned	1.70	4.08	2.39	3.23

Summary Report of All India Coordinated Research Project on Cashew

The All India Coordinated Spices and Cashewnut Improvement Project was started during the fourth Five Year Plan in 1971. During the Seventh Plan the ongoing All India Coordinated Spices & Cashewnut Improvement Project was bifurcated into two separate projects, one on Cashew and another on Spices. During the same Plan period the Coordinator's Cell for Cashew was located in National Research Centre for Cashew, Puttur, and for Spices in NRC-Spices, Calicut. The All India Coordinated Research Project on Cashew has seven centres of which four were started at the inception of AICS & CIP in the year 1971 (Bapatla, APAU; Anakkayam, KAU; Vengurla, KKV, and Vridhachalam, TNAU). During Fifth Plan period one centre at Bhubaneswar (OUAT) and two more were added during VI Plan (Jhargram, BCKVV and Chintamani, UAS.) The budget allocation of the Project for the year 1993-94 is Rs. 24.89 lakhs (Rs. 18.67 lakhs ICAR Share). During 1993-94 the expenditure was Rs. 25.92 lakhs (Rs. 19.43 lakhs ICAR Share).

The project's mandate is to give additional thrust to cashew research for increasing production and productivity through:

1. Evolving high yielding varieties with export grade kernels, tolerant/resistant to pests and diseases.
2. Standardizing agrotechniques for the crop under different agro climatic conditions
and
3. Evolving cost effective and effi-

cient pest and disease management practices

The XI Biennial Workshop of the project was held at UAS., Bangalore (Karnataka) during 18-20 Aug. 1993. The technical programmes decided at the Workshop were implemented by the centres. Summary of the results of current year are presented below.

CROP IMPROVEMENT

A total of 855 cashew germplasm accessions (Bapatla-127; Bhubaneswar-79; Chintamani-114; Jhargram-124; Madakkathara-120; Vengurla-161 and Vridhachalam-130) are being maintained and evaluated in different centres. In the germplasm evaluation the highest yield was recorded by T.No. 18/1 (66.2 kg), T.No. 3/33 (42.2 kg) and T.No. 10/19 (22.5 kg) of Bapatla; H-1608 (2.89 kg), BPP 2/16 (2.194 kg), Vengurla-2 (2.05 kg) and Vengurla-4 (1.98 kg) of Bhubaneswar; 3/108 Gubbi (22.5 kg), 5/37 Manjeri (21.7 kg), 13/5 Kodur (20.65 kg), ME 4/4 (17.55 kg), 2/77 Tuni (16.9 kg), 8/46 Taliparamba (14.05 kg) and 1/64 Madhuranthakam (10.50 kg) of Chintamani; JGM 71/5 (16.50 kg), JGM 24/2 (8.97 kg) of Jhargram; M 26/2 (8.3 kg) of Madakkathara, M 15/4 (23.5 kg) of Vridhachalam. The two hybrids H-1598 and H-1608 of Madakkathara are released as Kanaka and Dhana respectively. Dhana was accepted for release at national level during the XI Biennial Workshop. During the year a total of 72 new collections (Bapatla-4; Bhubaneswar-3; Chintamani-34; Jhargram-13; Madakkathara-5; Vengurla 13)

showing promising characters were added to the germplasm by different centres. From the old germplasm, a total of 239 accessions have been clonally multiplied and planted in the conservation block by Madakkathara (56) Vengurla (75) and Vridhachalam (108).

In multilocation trial, varieties collected from different centres are being evaluated. The highest yield was obtained from Bapatla-6 (8.99kg) at Chintamani; VTH-59/2 (6.73 kg), H-2/16 (5.89 kg) and VTH-30/4 (5.24 Kg) at Jhargram.

Evaluation of F₁ hybrids showed that two hybrids from Bapatla viz. HY 3/28 (T.No. 56 x M 10/4) and H 2/16 (T.No. 1 x T.No. 40) gave the maximum yield of 28.0 kg and 18.1 kg respectively.

A hybrid (HY 13, M26/2 x 26/4) from Vridhachalam recorded the highest mean yield of 4.50 kg/tree. Two hybrids from Vengurla (Hy. No. 255 and Hy. No. 367) gave the highest yield of 33.40 kg and 22.47 kg respectively.

CROP MANAGEMENT : A. AGRONOMY

In NPK trial, application of 500g nitrogen, 250g phosphorus and 250g potassium (N₂ P₃ K₃) per tree per year recorded the highest nut yield (13.68 kg/ha) compared to the control tree in Chintamani. In Jhargram 300g nitrogen, 200g phosphorus and 600g potassium recorded the maximum yield per plant.

Foliar application of urea along with insecticides (20%) has recorded the highest yield in Bapatla, Bhubaneswar and Jhargram centres, 9.6 kg/ tree with returns of Rs. 27,260/ha in Bapatla, 6.15 kg/plant in

Bhubaneswar and 6.09 kg in Jhargram respectively. The foliar nutrition of urea 4% along with endosulfan spray (T-4 treatment) registered the highest yield 6.35 kg/tree and the highest nitrogen content in Vridhachalam and 9.85 kg/tree at Vengurla centre respectively.

In spacing trial, the maximum yield per plant and yield per block were recorded in 10m x 5m rectangular system with 50% thinning of plants and 6m x 6m x 6m triangular system respectively in Jhargram centre.

In standardization of index leaf experiment in Bapatla, the third leaf from the top of a crown showed higher values of all the nutrients studied, maximum accumulation of nutrients was noticed at 60 days after fertilizer application and thereafter it declined. The lowest value of all the nutrients was observed at advance fruiting stage.

In the cashew based cropping systems, trial at Bapatla, with annuals, cluster bean has given an yield of 1200 kg/ha, cowpea 80 kg/ha respectively, tried during kharif, whereas the Rabi intercrops failed to come to maturity. In Vridhachalam CO.6 redgram gave the maximum yield of 313 kg/ha out of the annuals tried, but in red gram intercropped areas the growth of the main crop cashew, was found to be affected.

CROP MANAGEMENT : B. HORTICULTURE

Soft wood grafting was found to be the most successful method for vegetative propagation of cashew. The highest percentage of graft success was recorded during December (71%) and January (82%)

at Bapatla; September (76.25%), August (69.53%) and July (63.66%) at Bhubaneswar; September (44.8%), October (39.3%) and November (43.3%) at Chintamani; July (61%), August (65.5%) and September (59.0%) at Jhargram; January (75.1%) and December (63.1%) at Vridhachalam.

Zero energy sand humid chambers (trench method) covered with polythene sheet are found to be suitable for grafting purpose during rainless period and the maximum percentage of graft success (86.88%) was recorded during February and March at Bapatla.

A good graft success in top working was obtained at Bapatla (75%) and Bhubaneswar (63.3-84.0%). The success was low (7.6-36.1%) at Jhargram center. At Vengurla centre five year old top worked trees (10nos.) gave a mean yield of 8.64 kg/tree.

Screening of root stock for dwarfing characters at Madakkathara revealed that it is possible to identify the less vigorous from the more vigorous using morphological characters, phenolic contents in leaves, stomatal index, bark percentage in root as criteria at the seedling stage.

CROP PROTECTION

Treatment T-5 (spraying of monocrotophos 0.05% during flushing, endosulfan 0.05% during flowering and carbaryl 0.1% during fruiting stage) was found to be superior over other treatments in controlling tea mosquito bug and other pests at Bapatla, Bhubaneswar and Jhargram centers. Whereas, T-4 (spraying of monocrotophos 0.05% at flushing and endosulfan

0.05% at flowering stage) treatment was found to be superior at Chintamani centre, T-7 treatment (endosulfan at flowering and carbaryl at fruiting) at Vridhachalam and T-6 and T-7 treatments at Vengurla in control of major and minor pests.

In the trial on control of foliage/inflorescence pests of cashew with neem products, neem cake extract (5% spray) was found to be effective and remunerative at Bapatla centre, T-2 treatment (neem seed kernel extract 2%) followed by T-1 treatment (neem oil 2%) have recorded the minimum tea mosquito damage at Vridhachalam centre.

At Bapatla neem oil (5%) swabbing on the uninfested trunk during April month was found to be a good prophylactic measure for stem and root borer; Kaoline swabbing and application of sevidol (75 g/tree) + neem oil cake (3 kg/tree) + neem oil (5%) twice in a year is effective at Bhubaneswar; Sevidol 4g (150g/tree) and neem oil (5%) at Jhargram; sevidol (50g/tree) and neem oil (5%) at Madakkathara were effective against stem and root borer.

Survey for pest collection at Bapatla revealed that cashew plantations in high altitude areas of northern coastal districts of Andhra Pradesh are more prone to tea mosquito bug infestation followed by fungus than its counter parts in southern coastal districts. A pest calendar is also prepared by the centre. A moderate intensity of damage by tea mosquito bug was observed for the first time at Bhubaneswar. Two new insect pests of order Hemiptera (bugs) and two hymenopteran parasites were recorded in Chintamani centre.

Leaf and blossom webber, leaf miner and leaf thrips were found to be more injurious than tea mosquito bug in Jhargram and cashew growing tracks of West Bengal. In Madakkathara predators on cashew inflorescence noticed were spiders, mirid bug and chrysopa larvae.

Leaf and blossom webber were found to be heavily parasitized by *Brawn brevicornis* at Chintamani centre.

Screening of germplasm to locate tolerant/resistant types to major pests of the region have been carried out. V-5 showed the lowest infestation against shoot tip borer

at Bhubaneswar; Brazil-120, Brazil-239, Brazil-244, Anakkayam-1, Madakkathara-1, K-22-1, H-3-13, H-3-17, H-680, H-682, H-719, H-1596, H-1597, H-1598, H-1600, H-1602, H-1608, H-1610, M-1-2, A-26-2, K-16-1 were comparatively tolerant to tea mosquito bug at Madakkathara; In Vridhachalam H-1598 (among MLT entries), VR-49, NR-59, M-60/4, NR-34 (among new germplasm entries), recorded the least damage of tea mosquito bug incidence. V-2; M 26/2 were free from shoot and blossom webber damage, V-2, V-4, V-5, M-26/2, M 44/3 and M 59/2 were free from incidence of Ashweevil and M 9/3 (new germplasm entry) from damage of shoot and blossom webber.

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(As On 31-03-1994)

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Farm Superintendent	Sri K Lakshminarayana, B.Sc. (Agri.) T-6 (from 7.5.1993)
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PARTICIPATION IN SYMPOSIA/CONFERENCES

- | | | | |
|----|--|--|----------------|
| 1. | National seminar on use of plant growth regulators in Horticulture, Regional Fruit Research Station, Vengurla, Konkan Krishi Vidyapeeth, Dapoli, Maharashtra | MG Nayak | 10 Apr 1993 |
| 2. | RAC meeting of World Bank aided NARP Sub Direct on Horticultural Crop-Biotechnology, New Delhi. | EVVB Rao | 19-22 Apr 1993 |
| 3. | Seminar on "Cashew Cultivation", Panja, Sullia Taluk, Jointly organised by Syndicate Bank and Sullia Taluk Krishik Samaj | N Yadukumar
KRM Swamy
Sreenath Dixit | 1 May 1993 |
| 4. | Golden Jubilee Symposium on "Horticultural Research-changing Scenario", organised by Horticultural Society of India, at Bangalore | EVVB Rao
KRM Swamy
MG Nayak | 24-28 May 1993 |
| 5. | Group meeting on Cashew Development Programmes, organised by Commissioner (Hort.), Govt. of India, at Cochin | EVVB Rao | 06-08 Jul 1993 |
| 6. | XI Biennial Workshop of AICRP on Cashew held at UAS, Bangalore | EVVB Rao
PM Kumaran
KV Nagaraja
N Yadukumar
KRM Swamy
PS Bhat
MG Nayak
Sreenath Dixit
TN Raviprasad
Uma Jayaraman | 18-20 Aug 1993 |
| 7. | Seminar on "Arecanut, Coconut and Cashew", at Puttur, organised by Vijaya Rural Development Foundation, Puttur. | N Yadukumar
KRM Swamy
PS Bhat
Sreenath Dixit | 6 Sep 1993 |

- | | | |
|---|---------------------------|---------------|
| 8. XI Biennial Workshop of AICRP palms at Dona Paula, Goa. | EVVB Rao | Sep. 1993 |
| 9. RAC meeting of World Bank aided NARP Sub project on Horticultural Crop-Biotechnology, New Delhi | EVVB Rao | 8-10 Oct 1993 |
| 10. International Symposium on tropical tuber crops at CTCRI, Trivandrum | PS Bhat | 6-9 Nov 1993 |
| 11. Meeting on Development Programmes for cashew during VIII Plan, organised by Commissioner (Hort.), Govt. of India, at Hyderabad | EVVB Rao | 8-11 Nov 1993 |
| 12. Field day on cashew and ginger cultivation at Charuvaka, Puttur, organised by Department of Horticulture, Government of Karnataka | PS Bhat
TN Ravi Prasad | 20 Jan 1994 |
| 13. "Cashew Day and Seminar on Cashew" held at Nanoda, Panaji, Goa, Jointly organised by the Directorate of Agriculture, Goa, State Bank of India and Sagar Nursery | N Yadukumar
KRM Swamy | 17 Feb 1994 |

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2. Palanisamy, K, and Yadukumar, N., 1993. Photosynthesis in relation to radiation and leaf position in cashew trees **Photosynthetica** 29 (1) : 113-116.
3. Palanisamy K., Yadukumar N., and EVV. Bhaskar Rao 1993. Physiological characteristics of cashew in intercropped systems. **Plant Physiol and Biochem** 20(2): 99-101
4. Sundararaju, D. and Joy, N.J., 1993. Susceptibility of cashew accessions to *Helopeltis antonii* Sign (Heteroptera : Miridae), in the pre-flowering phase. **J. Plantation Crops** 21(1) : 50-53.
5. Swamy, KRM., Bhaskara Rao, EVV., Nagaraja, B. and Nayak, MG., 1993. Establishment and management of cashew scion bank. **The Cashew** 7 (3) : 3-6.
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5. Chadha K.L., Bhaskara Rao EVV 1993. Cashew Industry in India. In Golden Jubilee souvenir of Horticultural Society of India PP 65-68.

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2. All India Coordinated Research Project on Cashew. Annual Report 1992-93, pp 194 July 1993. (Compiled and edited by Sreenath Dixit, KV Nagaraja, KRM Swamy and Uma Jayaraman)
3. Bhaskara Rao, EVV, Swamy, KRM, Yadukumar N and Sreenath Dixit 1993. Cashew Production Technology. NRCC Tech. Bull. No.5, pp.36, (Aug 1993). National Research Centre for Cashew, Puttur.
4. Summary Report of XI Biennial Workshop of AICRP on Cashew 1991-93 Aug 1993, pp. 237, (Compiled and edited by EVV Bhaskara Rao and Uma Jayaraman)
5. NRCC Annual Report 1992-93, September 1993, pp. 87, (Compiled and edited by EVV Bhaskara Rao, K.V. Nagaraja and Sreenath Dixit).
6. Proceedings of XI Biennial Workshop os AICRP on Cashew. September 1993, pp. 104, (Compiled and edited by EVV Bhaskara Rao and Uma Jayaraman)
7. Cashew Production Technology (Compendium of Lectures) (Compiled and Edited by Sreenath Dixit and KRM Swamy) National Research Centre for Cashew, Puttur. Lecture Notes Series 8, pp. 52, (Jan. 1994).
8. NRCC Research Highlights 1993-94, March 1994, 16 pp. (Compiled and edited by EVV Bhaskara Rao, KV Nagaraja, and Sreenath Dixit)

RADIO TALKS DELIVERED

1. New cashew varieties and their characteristics (in K nnada)-Talk by KRM Swamy, Broadcast from All India Radio, Mangalore on 24 October 1993.
2. Pruning and its importance in cashew cultivation-Interview with M Gangadhara Nayak, Broadcast from All India Radio, Mangalore on 16th January 1994.
3. Maintenance of cashew plantation- Interview with Sri N Yadukumar, Broadcast on 17th January 1994 from All India Radio, Mangalore.

BOOKS/CHAPTERS

1. Bhaskara Rao, EVV and Swamy, KRM, 1993, Cashew genetic resources. In : **Advances in Horticulture-Plantation Crops**, Vol. 10 (Eds. KL Chadha and P Rethinam), Malhotra Publishing House, New Delhi.
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3. Bhaskara Rao, EVV 1993, Towards achieving self-sufficiency in cashew production. Article contributed to Souvenir published during Golden Jubilee Symposium on "Horticultural Research-Changing Scenario", held at Bangalore from 24-28 May 1993.
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5. Bhaskara Rao, EVV, 1994. Cashew : Problems of low productivity, **The Hindu : Survey of Indian Agriculture**, 1994, M/s. Kasturi and Sons, Madras.

IMPORTANT VISITORS

- 12 May 1993 Dr. P Rethinam, Asst. Director General (PC), New Delhi.
- 21 May 1993 D Verghese and team of officers from Regional Training Centre, NABARD, Mangalore.
- 05 Jul 1993 P C Nayak, IAS (Retired), Director, Centre for Technology Development, Bangalore.
- 19 Jul 1993 V Ranganathan, Technical Adviser, M/s. Ram Bahadur Thakur Limited, Vandiperiyar, Kerala.
- 17 Sep 1993 BC Thaosen, Secretary, Forest, Ecology and Environment, Government of Karnataka.
- 22 Sep 1993 W Krishnamurthy Rao, Head of the Department of Agronomy, CCRI Balehonnur.
- 25 Sep 1993 RN Singh, Former Director General, ICFRE, Dehradun.
- 30 Sep 1993 Dr. MV Rao, Vice-Chancellor, APAU, Dr. R Jayarajan, TNAU, Dr. T Maharana, OUAT and Dr. GK Veeresh, UAS, Bangalore - QRT for CPCRI and AICRP on plams.
- 28 Oct 1993 Dr. KC Devaraj Urs, Professor of Entomology, UAS, Bangalore.
- 16 Nov 1993 Dr. KVA Bavappa, FAO Expert, Dr. CC Abraham, Dr. G. Shanmugavelu, QRT for NRCC, Puttur.
- 26 Nov 1993 Dr. SHFW Justin, Research Fellow, Unit of Advanced Propagation System. Wye College, University of London.
- 22 Mar 1993 A team of journalists accompanied by Shri S.L. Sharma, Sr. Public Relations Officer, ICAR, New Delhi.

WEATHER DATA FOR 1993-'94

Month	Centre Temp (°C)		Humidity %		Total Rainfall (mm)	Rainy days	Sunshine (hours)	Evaporation (mm)	Wind velocity (Km/hr)
	Max.	Min.	FN	AN					
Apr.	35.8	24.7	88	48	0024.7	04	9.9	6.3	3.8
May.	36.1	NR	91	55	0154.6	09	7.9	4.8	3.4
Jun.	30.4	17.6	94	76	0490.6	20	4.6	3.4	3.2
Jul.	27.6	22.2	96	86	1305.2	29	1.6	2.4	2.4
Aug.	28.7	23.0	95	78	0659.1	23	2.6	3.4	2.4
Sept.	29.7	22.2	95	70	0168.4	11	3.5	3.6	0.7
Oct.	30.8	22.3	94	71	0293.0	17	6.1	3.1	0.6
Nov.	32.5	21.7	87	60	0049.9	03	7.8	3.8	1.6
Dec	31.4	20.1	89	53	0041.5	03	9.0	4.3	1.6
Jan.	33.2	19.3	90	41	0007.8	00	8.5	4.4	1.1
Feb.	34.0	20.5	93	39	0000.0	00	9.5	5.3	1.2
Mar.	36.1	23.1	90	39	0000.8	00	9.9	5.7	1.7
Total					3195.6	119			

ERRATA

Page	Column/ Table	Para	Line	Printed as	Read as
3	-	-	12	entrance	enhance
4	Col.2	2	1	net weight of	nut weight of
4	Tab.1	3	1-5	Deepal	Depal
11	Col.2	1	14	Year	2 years
11	Col.2	2	3	morphological	economic
15	Tab.16	-	4	H 16/18	H 6/18
			7	S 1618	S 16/8
17	Col.2	1	8	14.59	1459 µ
17	Col.2	2	10	1016	1016 µ
20	Col.1	2	3	formalarious	formulations
21	-	-	3	A net profit...	An increased net profit....
22	Tab.19	-	head- ing	kg/ha	kg/tree
23	Col.2	1	9	1992 & 1883	1992 & 1993
26	Col.1	3	11	PAR 97,300	PAR 97,330
32	Tab.31	-	1	WUV	WUE
43	-	-	6	redvid....	reduviid.....
43	-	-	7	<u>Sycanus collris</u>	<u>Sycanus collaris</u>
45	Tab.49	-	3	Lamanool+ Servidol	Limanool+ Sevidol
63	Tab.71	-	8	Lysine (ug/mg	Lysine (µg/mg
88	Col.1	3	11	1 percent Bor- deaux paste (10%)	Bordeaux mixture (1%)
89	Col.1	2	4	Rs.8.12 per tree	Rs.8 to Rs.12 per tree
93	Col.1	1	24	Rs.25.92 lakhs	Rs.25.91 lakhs
94	Col.1	4	1	(HY 13,M26/2x 26/4)	Hy 13 (M26/2x 26/4)
95	Col.1	5	3	endosulfan 0,05%	endosulfan 0.05%