

# CONTENTS

	Page
<b>DIRECTOR'S INTRODUCTION</b> .....	(i)
<b>CROP IMPROVEMENT</b> .....	3
Gen I (176) : Collection, Conservation and cataloguing and evaluation of cashew germplasm .....	4
Gen II (176) : Varietal improvement of cashew .....	6
Gen III : Tissue culture studies in Cashew for micropropagation and somaclonal variation .....	11
Adhoc scheme : Screening and biochemical evaluation of cashew germplasm in relation to tea mosquito infestation .....	13
<b>AGROTECHNIQUES</b> .....	19
Agr I(B) : Response of high yielding varieties of Cashew to different levels of nitrogen .....	20
Agr III(a) : Economic feasibility of micro irrigation (drip irrigation) and graded doses of NPK on the productivity of cashew .....	21
Agr IV : Cashew based cropping system - inter and mixed cropping with cashew .....	22
Agr V : Orchard management - comparison of hedge and square system of planting .....	25
Agr VI : Development of suitable cashew based cropping system .....	25
Agr VII : Comparative efficacy of slow release nitrogenous fertilizers for Cashew .....	26
Phy III : High density planting of cashew .....	26
Hort. II(a) : Demonstration of beneficial effects of pruning in cashew .....	28
Hort. IV : Studies on off-season graft production in cashew .....	29
Hort. V : Root stock studies in cashew .....	30
Hort. VI : Comparing the economics of topworking with replanting of cashew .....	31

<b>CROP PROTECTION</b> .....	33
Ent. V : Developing integrated pest management package against cashew stem and root borers .....	34
Ent. VII : Chemical control experiments against tea mosquito bug .....	35
Ent. VI : Biological control of tea mosquito bug and other sucking pests of cashew .....	40
<b>QUALITY ANALYSIS AND POST HARVEST TECHNOLOGY</b> .....	45
Biochem. I : Studies on biochemical changes during storage of cashew nuts and apples .....	46
<b>TRANSFER OF TECHNOLOGY</b> .....	51
Gen I (443) : Production of parental materials and breeders' stock of cashew .....	52
Extn I (443) : Training of extension and research workers and farmers .....	53
Extn IV (443) : Research-cum-Demonstration plots .....	54
<b>SUMMARY REPORT OF ALL INDIA COORDINATED CASHEW IMPROVEMENT PROJECT</b> .....	57
<b>GENERAL INFORMATION</b> .....	63
Staff of the Institute .....	65
Participation in Symposia/conference .....	67
Research Publications .....	68
Important visitors .....	71
Weather data .....	72

## 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 Cashew Improvement Project which is currently having seven centres functioning under State Agricultural Universities in different states.

## LOCATION

The headquarters of National Research Centre for Cashew is located 5 KM away from Puttur town (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 61 ha have been acquired. The newly constructed Laboratory-cum-Administrative building at Puttur was inaugurated by Dr. Balram Jakhar, Hon'ble Union Minister of Agriculture Government of India, on 25th November, 1991.

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

## 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 as under:

- \* Evolving high yielding varieties of cashew.
- \* Identification / breeding varieties for resistance/tolerance to pest such as tea mosquito.
- \* Evolving varieties with high protein, lysine and other biochemical parameters.
- \* Standardization of agrotechniques for achieving higher production and productivity.

- \* 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; 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 are deployed from CPCRI. This brings the staff component to 82 of which 70 positions are filled up. The sanctioned budget for the financial year 1991-92 was:

	Allocation Rs. (Lakhs)	Expenditure Rs. (Lakhs)
Non-Plan	31.00	29.42
Plan	60.00	59.75
AP Cess Fund	00.70	00.33
Revolving Scheme	00.87	00.84

## RESEARCH ACTIVITIES

Research Projects of this Research Centre have been organised into Crop Improvement, Agrotechniques, Crop Protection, Quality Analysis and Post Harvest Technology and Transfer of Technology. Besides research projects under these heads, a AP Cess Fund project on "Screening and biochemical evaluation of cashew germplasm in relation to tea mosquito infestation" and a Revolving Fund for production of grafts are also in operation. Salient results in different research projects are as under :

**Crop Improvement :** Research projects pursued under this have a common objective of evolving varieties with high yield 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.

Fourteen germplasm collections collected from East Godavari, Vishakapatnam and Shrikakulam, Districts of Andhra Pradesh and Regional Fruit Research Station, Vengurla,

Maharashtra, have been planted in the cashew gene bank which brings the total number of accessions in the cashew gene bank to 269. Performance of hybrids is better than the selfed progenies. A breeding block with ten lines and two NRCC selections has been established. A new trial with clonal material of nine released varieties has been laid out. Among the two recommended varieties planted during 1986, M 44/3 has been performing better than M 10/4. Single shoot formation was better in media supplemented with BAP. Bud bursting, elongation and formation of single shoot, however, was early in media supplemented with BAP and Kinetin (5 mg each/l). Callus could be induced from young shoots of mature tree and nucellar portion of ovular tissue. Biochemical changes are manifested as early as 6 hr after infestation by tea mosquito. Grafts with matured shoot are less preferred by tea mosquito for feeding and oviposition compared to tender and green shoot. Nymphal period was not affected when reared both on moderately susceptible and susceptible accessions.

**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.

Leaf N did not increase with increased application of N in an experiment on response of high yielding varieties of cashew to different levels of N. In the same experiment grafts continued to yield higher compared to the respective seedlings except A 18/4. Photosynthetic parameters like PAR, Pn, gs, E and WUE, and soil moisture content, have been recorded for cashew growing under different cropping systems. Different irrigation treatments have been shown to affect the morphological characters such as girth, height and spread. Results from high density planting have revealed that closer spacing reduced the net photosynthesis (PN). Transpiration (E) showed similar, but non significant, trend between different plant densities. Continued higher yield has been recorded in treatment wherein plant density is maintained at 625 trees/ha. Pruned trees gave higher yield compared to unpruned trees. Off-season grafting has been shown to be successful with green scion sticks of above 60 days during flushing and flowering period. The cost

of establishment and maintenance of top worked and replanted plants (0.2 ha) during first two years was Rs. 2086 and Rs. 1150 respectively.

**Crop Protection:** Research projects in crop protection programme attempt to develop integrated pest management packages against stem and root borers and effective chemical and biological control of tea mosquito and other sucking pests.

Results from a large plot prophylactic control trial on stem and root borers have indicated that neemark protected trees against stem borer for four months. Trees at early stage of infestation recovered when treated with EDB, kerosene and aluminium phosphide. Results from studies on *Beauveria bassiana* have indicated that direct spraying was most effective with mortality of 60 per cent.

Studies on chemical control trial with dust formulation have revealed that application of carbaryl 5 per cent, is most effective although the cost is higher. Compared to quinalphos and endosulfan, carbaryl and monocrotophos have higher residual toxicity. Survey on egg parasitoids of tea mosquito from three locations (Mane, Pane Mangalore and Konaje) has revealed the occurrence of two species of parasitoids (*Telenomus* sp and *Chaetostricha* Sp). A total of 23 species of parasitoid hymenopterans were collected and got identified by International Institute of Entomology, London.

**Quality Analysis and Post-Harvest Technology:** Studies on biochemical changes during storage of nuts and apples are being continued. Kernel sugar and starch content tend to decrease during storage both at low and ambient temperature. Lysine content also decreases while, protein did not follow any specific trend. CNSL content tend to decrease during storage. The relative concentration of three fractions of storage proteins did not change although, the ratio of albumin to globulin decreased initially followed by an increase. Sorbic acid, potassium metabisulphite and citric acid were not effective in extending the storage life of cashew apples.

**Transfer of Technology :** The projects under this programme contemplate to disseminate the technologies developed to

farmers and extension agencies through conducting training programmes, distribution of planting material, bringing out extension literature and establishing demonstration plots in collaboration with Directorate of Cashewnut Development, Cochin, and Srikrishethra, Dharmasthala.

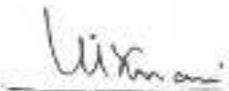
During the year a total of 31162 successful grafts have been produced. The highest percent graft success was recorded during September (81.8%) followed by August (77.3%) and October (65.1%). A total of 30215 grafts were sold during the year with a realisation of revenue of Rs.2,11,950. A total of 83 personnel which included 20 farmers and 63 officials were trained on Vegetative Propagation, Cashew Production Technology, Pest and Disease management, Training and Pruning in cashew and Forecasting of yield in cashew plantations. The total amount spent by the farmers for establishing and maintaining 0.8 ha cashew demonstration plot ranges from Rs. 3715 to 13070. The yield realised during fourth year ranged from 5 kg to 210 kg/0.8 ha plot.

**Library:** The library of this research centre has 605 reference volume and has been subscribing for 38 Indian and 9 International journals. During the year an amount of Rs. 1,54,852 has been spent towards strengthening the library facilities.

## ABOUT THIS REPORT

This is the sixth Annual Report brought out by this Research Centre. This has been compiled according to research projects taken up in Crop Improvement, Agrotechniques, Crop Management, Quality Analysis and Post-Harvest Technology and Transfer of Technology. In the following pages results of research projects of NRCC are summarised followed by summary report of All India Coordinated Cashew Improvement Project.

Puttur  
Dated 21st Sept. 1992

  
(M.K. NAIR)  
DIRECTOR



Inauguration of the Laboratory cum Administrative building by Dr. Balram Jakhar, Hon'ble Minister for Agriculture, Government of India, on Monday, the 25th November, 1991. Shri Mullappalli Ramachandran Hon'ble Union Minister of State for Agriculture and Cooperation also graced the occasion.



## CROP IMPROVEMENT

During the year 12 germplasm collection of bold nut types was made from Regional Fruit Research Station, Konkani Krishi Vidya Peeth, Vengurla, Maharashtra. With planting of 14 clonal accessions (collections from Maharashtra, West Bengal and Karnataka) the number of accessions in the cashew gene bank has gone upto 269. Based on the cumulative yield, germplasm accessions have been grouped. A total of 65 cross combinations and ten selfs are being evaluated. Under progeny trial I, three combinations have yielded more than 4 kg/year during seventh year of orchard life. Based on the cumulative mean yield, a total of 12 individual trees from progeny trial III have been identified as top yielders. A breeding block with ten different lines identified for boldnut, high yield, early bearing, short harvesting period, high shelling percentage and big apple has been established. A new clonal trial with eight recommended varieties has been initiated. Among the two recommended varieties planted during 1986, M 44/3 has been performing better than M 10/4 in terms of yield. Single shoot formation was better in media supplemented with BAP. Bud bursting, elongation and formation of single shoot, however, was early in media supplemented with BAP and Kinctin (5 mg/l each). In medium with NAA (2 mg/l) 57 per cent of zygotic embryos showed differentiation of plantlets. Studies on biochemical changes during shorter period of infestation have revealed that biochemical changes are manifested as early as 6 hr. after infestation by tea mosquito. Tea mosquito nymphs could be reared on cotton. Laboratory screening studies have indicated that VTH 153/1 is moderately susceptible to tea mosquito. Grafts with matured shoot are less preferred by tea mosquito for feeding and oviposition compared to tender and green shoot. Nymphal period was not affected when reared both on moderately susceptible and susceptible accessions.

# Gem. I(176) : Collection, Conservation, cataloguing and evaluation of cashew germplasm

(KRM Swamy and Thimmappaiah)

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

## Germplasm collection and conservation :

During the year 12 collections were made from Regional Fruit Research Station (Konkan Krishi Vidyapeeth), Vengurla, Maharashtra, and one collection from KCDC plantation, Kedimbady, Puttur. Of these 11 were bold nut types, one medium nut type and one small nut type (Table 1). The small nut type (Tulas) is free from CNSL and it is a cluster bearing type. Ten collections had big sized apple (> 70g). Softwood grafts of

these collections were prepared for planting in the gene bank. All the collections had apples of pear shape except Banda V which had apples of round shape.

Fourteen clonal accessions (NRC256-269) have been planted during June-July 1991 (6 softwood grafts/accession) with a closer spacing of 6m x 6m in the National Cashew Gene Bank. With this the total number of accessions so far planted in the germplasm conservation block/germplasm repository has gone up to 269 (Table 2). Of the fourteen accessions planted in the gene bank during June-July 1991, eleven were collected from Andhra Pradesh and one each from Maharashtra, West Bengal and Karnataka.

Table 1. Salient features of cashew germplasm collections made from Regional Fruit Research Station, Vengurla (Maharashtra) and KCDC, Puttur.

Name of collection	Age of tree (years)	No. of fruits/panicle	Apple colour	Apple weight (g)	Nut weight (g)
Vetore - I	4	3-5	Pink	70-80	12.6
Vetore - II	4	3-4	Pink	70-80	12.5
Kas	4	5-6	Red	50-60	7.0
Banda-V	4	1-2	Pink	70-80	11.5
Aakhane	4	1-2	Yellow	60-70	13.0
Vadkhal	4	2-3	Yellow	70-80	11.0
Bhuwash	4	1-2	Pink	70-80	11.0
Bhedasi	4	2-5	Yellow	100-110	11.5
Sirtal	4	1-2	Yellow	90-100	11.5
Humbarmal	4	2-5	Pink	70-80	11.5
Harche	4	4-6	Yellow	70-80	11.0
Tulas	4	10-20	Pink	20-30	4.5
Kedimbady	25	1-5	Pink	70-80	12.5

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

Source of collection	Number of Accessions		
	Existing	Planted during 1991	Total
Elite and diverse material selected from germplasm at:			
Vital	58	1	69
Shanthigodu	75	—	75
Primary Collections from:			
Karnataka	39	—	39
Andhra Pradesh	5	11	26
Tamil Nadu	8	—	8
Goa	40	—	40
Maharashtra	1	1	2
Orissa	9	—	9
West Bengal	—	1	1
Total	255	4	269

**Germplasm evaluation :**

Observations on stem girth at 15 cm from ground level were recorded for the cashew accessions planted during 1985, 1987, 1988, 1989 and 1990 (Table 3). The observations were recorded during January 1992. Majority of the accessions had stem girth ranging from 40.1 - 45.0 cm, 35.1 - 40.0 cm, 25.1 - 30.0 cm, 10.1 - 15.0 cm and 10.1 - 15.0 cm in the accessions planted during 1986, 1987, 1988, 1989 and 1990 respectively.

Based on the cumulative yield/plant recorded for the germplasm accessions planted during 1986, 1987 and 1988 accessions have been grouped and the data is presented in Table 4. In the accessions planted during 1986, the cumulative yield/plant ranged from 1001-2000 g in majority of the accessions (42.9%). In the accessions planted during 1987 and 1988, the cumulative or mean yield/plant was less than

Table 3. Stem girth of cashew accessions in the Cashew Gene Bank

Year of Planting	No. of accessions	Stem girth (cm)	Accessions	
			No.	%
1986	56	30.1 - 35.0	2	3.5
		35.1 - 40.0	7	12.5
		40.1 - 45.0	19	33.9
		45.1 - 50.0	14	25.0
		50.1 - 55.0	11	19.6
		55.1 - 60.0	3	5.3
1987	30	30.1 - 35.0	5	16.0
		35.1 - 40.0	12	40.0
		40.1 - 45.0	7	23.3
		45.1 - 50.0	4	13.3
		50.1 - 55.0	2	6.6
1988	67	20.1 - 25.0	18	26.8
		25.1 - 30.0	39	58.2
		30.1 - 35.0	10	14.9
1989	50	5.1 - 10.0	3	5.0
		10.1 - 15.0	31	51.6
		15.1 - 20.0	21	35.0
		20.1 - 25.0	5	8.3
1990	42	5.1 - 10.0	19	45.2
		10.1 - 15.0	23	54.7

Table 5. Performance of hybrids and selfs under Progeny evaluation trial - I

Hybrids	Parentage	Mean yield (kg/tree)				Mean Cumulative yield (5 yrs.)
		R-I	R-II	R-III	Mean 1991	
H-1	M 44/3 x M 44/3	2.2	3.5	4.2	3.5	12.7 (2.3)*
H-2	13/12 Sanyasi x M 44/3	4.0	2.6	3.5	3.4	12.1 (2.1)
H-3	A 18/4 x 7/10 Tetaguma	4.6	3.0	3.5	3.7	10.9 (1.9)
H-4	13/12 Sanyasi x 13/2 Sanyasi	3.2	1.6	3.5	2.8	8.4 (1.5)
H-5	Bla-139-1 x T.No.1	2.2	3.2	4.8	3.4	8.7 (1.5)
H-6	Bla-139-1 x 13/5 Kodur	6.0	4.3	3.4	4.7	10.1 (1.8)
H-7	M 10/4 x WBDC-V	2.5	3.2	2.9	2.9	9.8 (1.7)
H-8	M 37/3 x M 37/3	4.3	2.8	3.8	3.6	11.9 (2.1)
H-9	M 37/3 x A 18/1	4.2	2.6	3.4	3.8	9.9 (1.7)
H-10	M 37/3 x T.No.1	6.8	4.3	5.1	5.4	15.3 (2.7)
H-11	WBDC-V x WBDC-V	1.6	2.8	0.5	1.6	4.9 (0.8)
H-12	A 18/1 x A 18/1	2.5	3.7	1.0	2.4	6.3 (1.1)
H-13	A 18/1 x 13/5 Kodur	3.2	3.9	1.4	2.9	8.8 (1.5)
H-14	1/3 Ceylon x 13/5 Kodur	3.1	4.1	4.1	3.8	11.9 (2.1)
H-15	1/3 Ceylon x 1/3 Ceylon	2.8	2.0	3.3	2.7	8.7 (1.5)
H-16	1/3 Ceylon x A 18/1	3.1	4.7	4.9	4.2	11.2 (2.0)
H-17	M 37/3 x 13/5 Kodur	2.0	3.4	1.1	2.2	7.7 (1.3)
H-18	1/3 Ceylon x Mys. Kotekar	2.5	3.8	5.5	3.9	12.4 (2.2)
C-1	(Control) M 44/3 O.P.	0.9	1.4	2.2	1.5	5.6 -

CD - General Mean 1.71

\* Values in the parentheses indicate the ratio of mean cumulative yield of hybrid to mean cumulative yield of control.

3.0 kg. The yield of two combinations was less than 2 kg nut/tree/year. The cumulative mean of nine combinations was more than 10 kg/tree/year during their seventh year of orchard life.

### Progeny Trial - II

Observations on the trial planted with seven selfed lines (an observational trial) were continued for their economic characters. The individual tree yield of eight plants in two replication has been recorded and is presented in Table 6.

The highest mean yield (7.4 kg/tree/

year) for 1991 and the cumulative mean yield for five years (15.3 kg) was recorded in the selfed progeny of S-34 (T.No.1 of Bapatla) followed by 4.9 kg and 9.2 kg respectively in S-11 (M 10/4). The mean yield of S-20 (M 37/3) was least (1.8 kg/tree/year) showing an inbreeding depression with respect to nut yield.

### Progeny Trial - III

A total of 15 cross combinations and a control (M 44/3) planted in RBD arc being evaluated (four plants per plot in two replications). The tree wise yield data collected is presented in Table 7. The highest mean

**Table 6.** Performance of selfed lines under progeny evaluation trial - II

Selfed lines	Description	Mean yield (kg/tree)			Mean cumulative yield (5 years)
		R-I	R-II	Mean	
S-11	M 10/4	4.5	5.3	4.9	9.2
S-12	M 44/3	2.5	2.4	2.5	6.8
S-16	M 16/1	5.3	2.8	4.0	9.1
S-20	M 37/3	1.3	2.4	1.8	5.2
S-34	T.No.1	7.9	6.9	7.4	15.3
S-120	1/3 Ceylon	4.4	1.5	2.9	6.2
S-127	T.No.270	2.7	3.4	3.0	5.8

**Table 7.** Performance of the hybrids under progeny evaluation trial - III

Hybrids	Parentage	Mean yield (kg)		General mean	Mean Cumulative yield (5 years)
		R-I	R-II		
H-19	A 18/4 x B1a-139-1	2.2	2.2	2.20	9.0 (6.4)*
H-20	B1a-139-1 x M 10/4	6.6	5.7	6.11	14.8 (10.5)
H-21	A 18/4 x M 10/4	1.3	2.5	1.90	6.5 (4.6)
H-22	A 18/4 x Vettore-56	1.7	2.2	2.00	7.3 (5.2)
H-23	7/10 Tetagunta x A 18/4	2.1	2.1	2.10	4.2 (3.0)
H-24	B1a-139-1 x A 18/4	1.9	2.6	2.20	6.6 (4.7)
H-25	7/10 Tetagunta x B1a-139-1	2.9	2.7	2.80	6.4 (4.6)
H-26	M 37/3 x 7/10 Tetagunta	2.3	1.8	2.10	4.7 (3.3)
H-27	M 44/3 x 9/8 EPM	2.1	5.9	4.00	8.1 (5.8)
H-28	M 16/1 x 13/5 Kodur	3.6	3.1	3.40	5.6 (4.0)
H-29	T.No.1 x 7/10 Tetagunta	1.6	1.8	1.70	3.4 (2.4)
H-30	WBDC-V x M 10/4	0.6	3.3	1.90	4.1 (2.9)
H-31	Mysore Kotekar x 13/5 Kodur	1.0	1.4	1.20	3.9 (2.8)
H-32	T.No.1 x M 10/4	3.6	1.6	2.10	5.7 (4.1)
H-33	WBDC-V x 13/5 Kodur	1.7	0.5	1.10	3.4 (2.4)
C-III	M 44/3 OP (Control)	1.4	-	0.70	1.4

CD General Mean : 2.1

\* Values within parentheses indicate the ratio of mean cumulative yield of hybrid to mean cumulative yield of control.

cumulative yield (14.8 kg, 10.5 times the control) and mean yield of 1991 (6.11 kg, 8.7 times the control) was recorded in H 20 (B1a 139-1 x M 10/4). The least yield was recorded in control (M 44/3).

In this trial the yield of seven combinations was less than 2 kg/tree while it ranged between 2.1 kg and 3.0 kg in six combinations. The yield of three combinations was more than 3 kg in the seventh

year of planting.

Based on the mean cumulative yield of five years (1987-1991), a total of 12 individual trees have been identified as top yielders. The highest cumulative yield (27.2) and mean yield (14.6 kg) was recorded in H 20/3 (Bla 139-1 x M 10/4) and in S-34/3 (T.No.1 self) respectively (Table 8).

In another trial of hybrid progeny evaluation (145 nos.) planted at Kemminje, during 1987 with closer spacing (6m x 6m), Tree Nos. 34 (VTH 12 x VTH 30) 42 (VTH 30 x VTH 11), 39 (VTH 36 x VTH 30) and 10 (VTH 36 x VTH 30) showed a yield potential of over 1.5 kg/tree. The size of the nuts from these trees was medium to bold.

#### Second phase hybridization :

Hybridization programme for the improvement of released varieties mainly

for the nut size was continued and a total of 270 hybrid seeds from five combinations were sown in the nursery. The germination percentage varied from 5.9 to 62 percent (Table 9). From this a total of 116 hybrid seedlings and one self have been planted in the field at closer spacing of 6m x 6m along with open pollinated seedlings of the parents for evaluation. During the current season a total of 1800 flowers were pollinated with the pollen of three selected lines from germplasm and initial fruit set recorded was 17.1 per cent.

#### Clonal evaluation of hybrids/selections :

Based on the treewise nut yield, weight of the nut, shelling percentage and cumulative mean yield of five years (1987-91) a total of seven promising hybrids were selected from Vittal (5 nos.) and Puttur (2 Nos.). These selected hybrids will be evaluated along with the two NRCC selections,

Table 8. Details of promising hybrids/self selected based on individual tree performance (Trial I, II and III).

T.No.	Description	Cumulative yield (kg/tree)	Yield of 1991 (kg/tree)
H-5/9	Bla-139-1 x T.No.1	15.1	8.6
H-6/2	Bla-139-1 x 13/5 Kodur	21.0	10.6
H-8/16	M 37/3 - Self	14.5	9.0
M 10/4	M 37/3 x T.No.1	17.4	11.7
H 14/14	1/3 Ceylon x 13/5 Kodur	19.1	9.1
H 10/6	M 37/3 x T.No.1	23.7	9.0
H 18/7	1/3 Ceylon x Mys. Koteekar	21.5	8.9
H 18/14	1/3 Ceylon x Mys. Koteekar	24.6	8.6
H 20/3*	Bla 139-1 x M 10/4	27.2	9.9
S 164**	M 16/1 Self	16.9	8.6
S 34/3**	T.No.1 Self	20.5	14.6
S 34/4**	T.No.1 Self	15.2	8.5

\* From Progeny trial - III

\*\* From Progeny trial - II

VTH 174 and a control (M 44/3). The details of the hybrids selected for evaluation are given in Table 10. The grafts of the above lines are ready for field planting.

#### Establishment of Breeding Block:

A total of 10 different lines identified for various characters like bold nut, high yield, early bearing, short harvesting period, high shelling percentage and big apple have been planted in the field along with two NRCC selections (10 plants/line). The details of the lines planted and their characters are given in Table 11.

#### Clonal evaluation of Released/Recommended varieties :

In the trial planted with clonal material of 12 recommended varieties at Puttur (1986 planting), the yield difference among the varieties was significant. In the fifth year of orchard life, M 44/3 continued to yield better than others with an average yield of 0.9 kg/tree followed by M 10/4 (0.6 kg/tree), 9/8 EPM (0.58 kg/tree), and Bla-39-4 (0.55 kg/tree).

In the clonal trial of 14 high yielding and medium nut types and a control

Table 9. Details of hybrid combinations, percentage of germination, and seedlings planted in the field.

Cross combinations	No. of seeds sown	No. germinated	% of germination	Seedlings planted in the field
M 44/2 x VTH 711/4	47	8	5.9	2
M 44/3 x VTH 40/1	87	54	62.1	45
Bla-139-1 x VTH 711/4	51	32	59.1	30
V-5 X VTH 711/4	66	41	62.1	31
Bla-139-1 x VTH 40/1	16	9	56.0	8
V-5 Self	5	2		1
Total	275	146	53.3	117

Table 10. Details of NRCC hybrids/selfs proposed for evaluation

Hybrids	Hybrid combination	Mean nut wt. (g)	Kernel wt. (g)	Shelling %	Yield of 1991 (kg)	Mean Cumulative yield (5 years) (kg)
H 6/1	Bla-139-1 x 9/8 EPM	8.0	2.2	28.0	4.5	10.2
H 32/4	T.No.1 x M 10/4	8.7	2.1	25.0	7.4	15.3
H 15/4	1/3 Ceylon x 1/3 Ceylon	7.9	2.2	28.0	2.1	7.8
H 17/11	M 37/3 x 139 Kodur	8.1	2.2	28.0	1.5	3.5
H 23/1	7/10 Telegorta x A 18/4	7.9	1.9	25.0	3.7	9.1
H 79**	M 44/3 x A 18/4	10.1	2.3	22.7	1.0	2.2*
H 39**	T.No. 56 x A 18/4	9.2	2.2	25.6	0.7	2.7*

\*\* Hybrids selected from Puttur (1987 planting)

\* Yield for initial three years.

(M 44/3) at Shanthigodu (1988 planting), the morphological observations showed no significant difference. The maximum growth, however, was observed in 13/5 Kodur.

A new clonal trial of eight recommended varieties has been planted in the field with a control (M 44/3) in a randomised block design. The planting has been done at six plants per plot in four replications. The details of recommended varieties planted in the field are presented in Table 12.

Table 11. Details of Accessions planted in Breeding Block

Description	Character for which selection was made
Karkodi	Big nut size
VTH 50/2	Earliness
VTH 139/1	Big apple
H 5/8	Shortest harvesting period
VTH 135/1	Yield and shelling
VTH 79/2	High yield and shelling
Vesore-56	Big nut size
VTH 711/4	Big nut size
155 L	Apple, nut size and yield
VTH 570	High shelling
NRCC-I	Yield, shelling and nut size
NRCC-II	Yield, shelling and nut size

#### Maximisation of yield plot:

Among the two released varieties (M 10/4 and M 44/3) of cashew, planted in 1986 with their clonal material at Puttur, M 44/3 showed superior performance over M 10/4. It gave an average yield of 2.1 kg/tree against the 0.8 kg/tree of M 10/4 in the fifth year after planting. In a plot of 0.6 ha, the yield realised was 149 kg (248 kg/ha) with an average of 1.5kg/tree. The cost of cultivation worked out for the fifth year of planting was Rs. 2583/plot (Rs. 4305/ha).

Table 12. Details of the second set of recommended varieties under clonal evaluation

Description	Control	Mean Yield (kg)	Mean nut wt (g)	Shelling %
K-22-1	Madakkathara	13.0	6.0	23.0
NDR 2-1	Madakkathara	17.0	6.0	28.0
V 1	Vengarla	23.0	6.3	31.0
V 4	Vengarla	14.0	7.1	31.0
Ullal 2	Ullal	18.0	6.0	30.5
BPP-3	Bapatla	16.0	4.8	28.1
NRCC-I	Puttur	10.0	7.6	28.8
NRCC-II	Puttur	8.8	9.2	28.6
VRI-II	Vridhachalam	6.0	6.0	30.5
(M44/3)	(Control)			

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

(Thimmappaiah)

The project was initiated during 1990-91 with the objective of standardising micropropagation technique for rapid

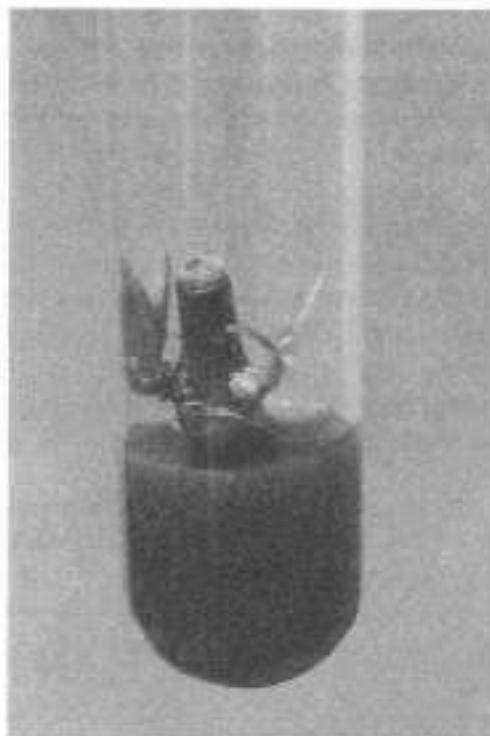
multiplication of cashew elite lines and to undertake studies on somaclonal variation to increase variability and select

somaclonal variants which are of breeding value.

#### **Micropropagation :**

Shoot-tips and nodal cuttings (single and double node) excised from young cashew seedlings were cultured on MS medium supplemented with BAP (0, 0.5, 2, 5, 10 mg/l), BAP + NAA, BAP + Kinetin and BAP + IBA. Although for bud extension basal medium alone was sufficient, the cultures with this turned yellowish in the later stage. As compared to media supplemented with BA (5 mg/l) alone, media supplemented with BA and Kinetin (5mg/l) showed better initiation and growth of cultures. In the latter 90 per cent of the explants formed single shoots within 2 to 3 weeks as against 60-70 per cent in the former. Addition of IBA (1-2 mg/l) to the latter resulted in proliferation of axillary buds. Cotyledonary nodes excised from 15 days old seedlings without their cotyledonary segments also showed multiple shoot induction in media containing both kinetin, BA and IBA.

Establishment of shoot cultures from 5-6 years old trees posed problems due to early necrosis/browning of tissue and higher rate of contamination. The response in bud activation was seen only in 10-20 per cent of explants. Clonal propagation through somatic embryogenesis was also attempted by culturing immature zygotic embryos and nucellus (ovule culture) on a modified MS medium supplemented with 2,4-D (1, 4 mg/l). Callus was induced both from nucellus (30-70%) and zygotic embryos. About 10 to 15 percent of these cultures showed the formation of somatic embryos in the induction medium and at



Multiple shoot induction from cotyledonary node on MS medium

reduced levels of 2, 4 -D. Maturation and differentiation of somatic embryos in the differentiating media tried showed prominent root formation and poor shoot differentiation. Immature zygotic embryos in hormone free medium showed either organogenesis or somatic embryo formation. In medium with NAA (2mg/l) 57 per cent of zygotic embryos showed differentiation of plantlets.

#### **Callus culture :**

Callus has been induced from green cotyledonary segments (mature nut), leaf, shoot and epicotyl portion of young cashew seedlings on a modified MS medium supplemented with 2, 4 -D (0.5, 1, 2, 4 and 8 mg/l). Callus formation was profuse at 4

mg/l of 2, 4-D and at lower concentrations, the callus initiation was less and rhizogenesis was prominent. Callus in the initial stage was white in colour and turned brown at later stages. Addition of coconut water

at 15 per cent (v/v) was beneficial in callus induction. NAA at 1 to 10 mg/l in the medium did not support the callus formation. Callus was also induced from young shoots of mature trees, of 5 to 6 years old.

### Adhoc Scheme : Screening and biochemical evaluation of cashew germplasm in relation to tea mosquito infestation.

(KV Nagaraja, D Sundararaja and Joy N John)

The project was initiated in 1988 with an objective of screening the accessions for tea mosquito tolerance and to study biochemical changes during infestation.

Biochemical changes in tender tissues during shorter period of infestation were continued. Changes in the leaf starch content during shorter period of infestation were followed and the results are presented in Table 13. Leaf starch content increases initially followed by a decrease. Response was noticed as early as 6 hr after infestation. This is in conformity with our earlier observation on other biochemical con-

stituents like sugars, phenols and orthodihydroxy phenols. Damage score also increases with period of infestation. Total lipids have been shown to increase initially followed by a decrease. Fractionation and characterisation of individual class of lipids is in progress.

Changes in the electrolyte leaching and its composition during shorter period of infestation were studied and the results are presented in Table 14. Electrolyte leaching as measured by conductance increases with infestation. The composition of leachates, with respect to sugars, phenols and orthodihydroxy phenols, however, shows an initial increase followed by a decrease. Damage score increases with period of infestation. Results indicate the possibility of the damage to the cellular membrane resulting in increased leakage of ions and other low molecular weight compounds. These studies also have indicated that biochemical changes are manifested as early as 6 hr after infestation by tea mosquito. The extent of damage caused by tea mosquito is directly reflected in the resulting biochemical changes indicating the direct relationship between the damage caused and the resultant biochemical changes.

Table 13. Changes in leaf starch content during shorter period of infestation.

Period of infestation (hr)	Damage Score (0-4 scale)*	Starch content (mg/g fr. wt)
0	-	21.67
6	1.4	30.82
12	1.8	22.69
18	2.4	17.49
24	2.6	18.68

\* 0 - No damage, 1 - 10 per cent area damaged, 2 - 11 to 25 per cent area damaged, 3 - 26 to 50 per cent area damaged or partial or complete wilting of one of the leaves, 4 - 51 to 100 per cent area damaged or wilting of more than one leaf.

**Table 14.** Electrolyte leaching and its composition in leaf during infestation by tea mosquito

Period of infestation (hr)	Damage score (0.4 scale)**	Specific conductance ( $\mu$ Mhos/g fr.wt/30 min)	Sugars (mg/g fr.wt)	Phenols ( $\mu$ g/g fr.wt)	Orthodihydroxy phenols ( $\mu$ g/g fr. wt)
0		137.55	1.08	60.7	15.3
5	0.8	406.68	1.92	138.4	40.7
12	1.0	370.06	0.93	171.3	57.9
18	1.8	860.47	1.76	95.5	49.6
24	2.0	383.14	1.06	106.1	20.0
72	3.2	552.40	0.63	80.9	29.3
120	4.0	1097.50	0.54	67.2	22.0

\* Damage score as in Table 13.

The three hybrids which were identified as moderately susceptible to tea mosquito have been characterised for their phenols and orthodihydroxy phenols contents and the results are presented in Table 15. Among the three hybrids, H 28/1 had highest phenols and orthodihydroxy phenols contents.

#### Entomological studies :

Culturing of tea mosquito bug (TMB) : During the period under report, a total of 2879 nymphs were reared. The percentage

of nymphs reached adult stage ranged from 56.9 to 93.5 per cent. The results are presented in Table 16.

**Table 15.** Biochemical characterisation of tender shoots of moderately susceptible accessions

Accession	Phenols (mg/g fr. wt)	Orthodihydroxyphenols ( $\mu$ g/g fr.wt)
H 24/7	0.272	46.0
H 28/1	0.305	52.8
H 22/6	0.229	25.6

**Table 16.** Culturing of TMB in the laboratory

Month	No. of nymphs reared	No. of nymphs used for biology	No. of nymphs used for biochemistry	% of nymphs reached adult stage	Sex ratio	
					Female	Male
Jun 91	417	417	-	86.8		1:1
Jul 91	239	239	-	70.3		1:1
Aug 91	123	123	-	93.5		1:1.1
Sep 91	333	333	-	86.8		1:1
Oct 91	428	408	20	88.0		1:0.8
Nov 91	323	238	90	64.0		1:1
Dec 91	214	130	84	83.1		1:0.8
Jan 92	153	114	44	81.6		1:1
Feb 92	330	255	84	88.4		1:0.8
Mar 92	232	157	105	66.9		1:1
Apr 92	48	-	48	-		-
Total	2879	2414	473	81.5		1:1

Since cotton is reported as one of the host plants of tea mosquito bug, rearing of TMB was undertaken on tender shoots of a glabrous cotton variety (Suvi). The results indicated that 65.9 per cent of nymphs could reach adult stage on cotton (Table 17).

Table 17. Biology of TMB in cotton and cashew

Host	No. of nymphs reared	% of nymphs reached adult stage	Sex ratio	
			Female	Male
Cotton	41	65.9	1	0.6
Cashew	38	80.0	1	0.6

#### Screening of cashew accessions against Tea mosquito bug:

For screening, soft wood grafts of seven accessions were used. The grafts of all accessions (10 grafts/each accession) were arranged at random inside the bigger metal wire cage of 2 x 2 x 2 m size. One nymph (4th or 5th instar)/graft was individually released and adult population (two/graft) were also released inside the metal cage. After 72 hr of feeding, all the grafts were removed and kept in the nursery and damage was recorded after one week. The results indicated that VTH 153/1 has shown moderately susceptible reaction in the present screening experiment (Table 18). However, H 24/7, H 28/1, H 32/6, G 11/6, had shown consistently moderately susceptible reaction in earlier screening experiments.

#### Detailed studies on variation of tolerance with regard to biology and bionomics of TMB:

Variation of damage, oviposition on different phenological stages of the growth:

Table 18. Screening of cashew accessions against TMB

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

Four moderately susceptible accessions identified earlier by laboratory screening and one susceptible accessions were utilized for assessing the variation at different phenological stages of the growth. In each laboratory screening cage, four grafts of each accession having four different phenological stages viz., (1) matured shoot, (2) just flushing (3) tender shoot and (4) green shoot, were arranged and two mated pairs of four days old were released. After 48 hr the grafts were removed and number of eggs were counted and the damage was assessed after one week. The results (Table 19) indicated that the grafts having matured shoot recorded least damage as well as least oviposition which may be due to feeding deterrent and oviposition resistant factors. The vulnerable stage for damage as well as most preferred stage for oviposition were seen on tender shoot and green shoot respectively. The tolerance reaction is seen in the green shoot stage in all the moderately susceptible accessions except in H 32/6 accession.

Variation of damage and oviposition of fresh tender and already damaged green shoots: Under field condition already

Table 19. Damage and ovipositional preference on different phenological stages of cashew

Name of the accession	Damage (0-4 scale) on								No. of eggs/graft layed on			
	Shoot				Leaf				M	JF	TS	GS
	M	JF	TS	GS	M	JF	TS	GS				
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
Susceptible	0.5	3.5	3.8	3.2	-	3.5	3.5	2.5	2.0	2.0	5.8	6.2
Mean	0.5	3.5	3.8	3.0	0.1	3.2	3.5	1.6	1.2	4.6	7.7	8.4

M - Matured shoot      JF - Just flushing  
 TS - Tender shoot      GS - Green shoot

damaged green shoots, even before production of new growth, were found to harbour nymphs of different instars and adults of TMB. In order to ascertain any oviposition and feeding preference is existing on the already damaged green shoots, two pairs of mated adults of four days old were released in each screening cage containing two grafts each having fresh tender shoots and already damaged green shoots of moderately susceptible accession, G 11/6. After 48 hr the grafts were removed and the number of eggs layed and damage were recorded. Even though, grafts with fresh tender shoots are most preferred for oviposition, already damaged green shoots also harbour sizable number of eggs (8.5 per graft) which can influence the population build up under field condition (Table 20).

Variation of nymphs on fresh tender and already damaged shoots: In order to find out the variation in number of nymphs reaching adult stage two types of shoots

(fresh tender shoot and already damaged green shoot) were used. Nymphs were reared from first instar to fifth instar on fresh tender shoots of a moderately susceptible accession (G 11/6) and simultaneously rearing was done on already damaged green shoots with nymphs of third to fifth instar collected from field surviving on already damaged green shoots of same accession. The results indicate that even though green tender shoots are favourable for nymphal growth, the already infested green shoots are comparatively equal in supporting the growth of the nymphs with some variation only in sex ratio (Table 21).

Biology of TMB in moderately susceptible and susceptible accessions: The first instar nymphs were reared on tender shoots of two moderately susceptible accessions (G 11/6 and Kunthur-24) and on a susceptible check upto adult stage. The results indicate that there is no variation on nymphal period (Table 22).

Table 20. Ovipositional preference studies on fresh and already damaged grafts of moderately susceptible accession (G 11/6)

Damage and No. of eggs laid	Fresh grafts	Already damaged grafts
Mean Damage (0-4 Scale)		
Shoot	3.0	3.0
Leaf (a) Petiole and Midrib	1.5	1.6
(b) Lamina	0.8	1.4
Mean No. of eggs/graft		
Shoot - previous season's growth	2.9	0.7
current season's growth	1.9	2.9
Tender shoots	1.6	1.9
Matured leaf (i) Petiole	1.6	0.3
(ii) Midrib	-	-
Tender leaf (i) Petiole	3.1	1.7
(ii) Midrib	7.4	1.9
Total	18.7	8.5
Percentage	68.8	31.2

Table 21. Survival of TMB nymphs on fresh and already damaged shoots of moderately susceptible accessions (G 11/6)

Host material	No. of nymphs reared	% of nymphs reached adult stage	Sex ratio Female : Male
Fresh shoots	107 (I instar)	81.3	1:0.9
Damaged shoots	82 (III to V instar)	74.4	1:1.6

Table 22. Biology of TMB in moderately susceptible and susceptible accessions

Accession	No. of nymphs reared	No. of nymphs reached adult stage	Nymphal period (days)	
			Male	Female
G 11/6	20	17	12.4 (10-14)*	13.0 (11-15)
Kumar 24	20	18	11.8 (10-14)	12.1 (11-14)
Susceptible check	20	18	12.3 (11-14)	12.6 (11-14)

\* Figures within parentheses indicate the range.

## AGROTECHNIQUES

In an experiment on response of high yielding varieties of cashew to different levels of N, the leaf N did not increase with increased level of N application. Grafts gave better yield than seedlings of the same variety. Different irrigation treatments have been shown to affect the morphological characters such as girth, height and spread. Photosynthetic parameters like PAR, Pn, gs, E and WUE, and soil moisture content have been recorded for cashew growing under different cropping systems. Results from high density planting have revealed that closer spacing reduced the net photosynthesis (PN). Transpiration (E) showed similar but non-significant trend between different plant densities. Pn, gs and E had linear relationship. Continued higher yield has been noticed in treatment wherein plant density is maintained at 625 trees/ha. Pruned trees gave higher yield than unpruned trees although the yield both in pruned and unpruned trees was low during last year. Off season grafting has been shown to be successful with green scion sticks of above 60 days during flushing and flowering period. Per cent success of softwood grafts was similar both under normal method and low cost humidity chamber. A field trial will be laid out with softwood grafts of NRCC Selection-1 on root stock raised from seedlings of vigorous and less vigorous types. The cost of establishment and maintenance of top worked and replanted plots (0.2 ha each) during first two years was Rs. 2086 and Rs. 1150 respectively.

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

(N Yadukumar)

This experiment aims at evaluating the eight promising selections identified from germplasm collection of cashew available at Vittal for various characters. The experiment was planted at Vittal during 1983 with eight 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 variable factors are (i) three levels of N viz., 250, 500 and 750 g/plant/year and (ii) two types of planting materials viz., seedling and grafts. The trial was laid out in a split plot design with two replications.

**Leaf N content**

The leaf N content did not increase significantly with the increased application of N from 250g N to 750g N/tree. Increasing trend in N from 1.48 per cent to 1.54 per

cent was, however, observed in plants receiving 250g and 500g N/tree respectively. The leaf N content did not vary significantly among varieties also (Table 23).

**Yield**

In general the grafts yielded better than the seedling progenies of the same varieties except A 18/4 where grafts continued to yield less compared to seedling progenies. Among grafts, maximum yield was recorded in M 6/1, followed by T.No. 1 and BLA-139-1. In the seedling population the maximum yield was recorded in M 6/1 followed by A 18/4 and BLA 139-1. The mean yield of nuts/tree increased with increased N application from 250g to 750g N/tree (Table 24).

**Table 23. Leaf N content (%)**

Varieties	N levels (g)			Mean
	250	500	750	
	WBDC-V	1.52	1.59	
M 6/1	1.45	1.51	1.52	1.49
M 10/4	1.49	1.64	1.53	1.56
M 44/3	1.50	1.60	1.54	1.55
A 18/4	1.57	1.55	1.54	1.55
T.N.O. 1	1.46	1.52	1.60	1.53
Kodur 13/5	1.41	1.47	1.61	1.50
BLA-139-1	1.50	1.52	1.46	1.48
Mean	1.48	1.54	1.54	

**Table 24. Nut yield (kg/tree)**

Varieties	N levels (g)			Seedlings	Grafts
	250	500	750		
WBDC-V	2.08	2.51	2.35	2.39	2.23
M 6/1	2.95	4.89	5.29	3.77	4.65
M 10/4	2.15	2.21	2.78	2.05	2.71
M 44/3	1.96	2.86	3.40	2.60	2.87
A 18/4	2.08	2.62	2.98	3.42	1.70
T.N.O. 1	2.57	2.56	3.50	2.44	3.18
Kodur 13/5	2.25	1.75	3.04	2.36	2.33
BLA-139-1	2.51	2.85	3.65	2.96	3.04
Mean	2.29	2.77	3.37	2.74	2.85
CD for sub plot	1.22				
main plot	Not-significant				

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

(N Yadukumar)

The experiment on micro-irrigation cum graded doses of fertilizers was laid out in split-plot design with four replications in 1989 at Experimental Station, Shantigodu. The treatments included are as follows : Main plots- (1) Control (no irrigation  $I_1$ ), irrigation once in four days through drip system (2) at 25 litres  $I_2$ , (3) 40 litres  $I_3$ , (4) 50 litres  $I_4$  and (5) 80 litres/tree  $I_5$ . Sub plots - (1) Control-no fertilizer ( $M_1$ ), (2) 250g N, 52.5g  $P_2O_5$  and 52.5g  $K_2O$  ( $M_2$ ), (3) 500g N, 125g  $P_2O_5$  and 125g  $K_2O$  ( $M_3$ ), (4) 750g N, 187.5g  $P_2O_5$  and 187.5g  $K_2O$  ( $M_4$ ).

**Morphological characters**

Observations on growth showed increased height (Table 25), girth (Table 26) and spread (Table 27) in case of irrigated plants as compared to plants growing without irrigation. Among the irrigation treatments ( $I_1$  to  $I_5$ ) however, the difference was not significant with reference to all the above growth characters. Increased values in growth measurements as compared to control plants have been observed. Among the NPK fertilizer treatments ( $M_2$  to  $M_4$ ), however, the difference was not observed. Observations on ground coverage (canopy spread) showed that there is two fold increase in canopy spread of irrigated plants as compared to unirrigated plants. Among the fertilizer treatments marginal increase in values on growth characters (girth, height and ground coverage) have been observed as compared to unfertilized plants.

**Table 25. Height of cashew under different treatments (m)**

Irrigation treatments	Fertilizer treatments				Mean
	$M_1$	$M_2$	$M_3$	$M_4$	
$I_1$	2.0	2.2	1.9	1.9	2.0
$I_2$	2.4	2.4	2.5	2.5	2.5
$I_3$	2.4	2.4	2.5	2.5	2.5
$I_4$	2.6	2.3	2.5	2.5	2.5
$I_5$	2.6	2.4	2.6	2.5	2.5
Mean	2.40	2.34	2.40	2.42	2.40

**Table 26. Girth of cashew under different treatments (cm)**

Irrigation treatments	Fertilizer treatments				Mean
	$M_1$	$M_2$	$M_3$	$M_4$	
$I_1$	15.80	19.00	17.15	15.95	16.47
$I_2$	20.00	20.90	22.00	21.50	21.10
$I_3$	21.90	19.50	19.50	20.36	20.32
$I_4$	21.45	23.50	21.75	21.15	21.96
$I_5$	22.55	22.40	23.10	22.15	22.55
Mean	19.94	21.06	20.70	20.22	20.47

**Table 27. Ground coverage of cashew under different treatments (square m)**

Irrigation treatments	Fertilizer treatments				Mean
	$M_1$	$M_2$	$M_3$	$M_4$	
$I_1$	2.71	4.08	2.83	3.17	3.19
$I_2$	4.71	5.22	6.51	5.73	5.43
$I_3$	6.60	5.96	4.52	6.69	5.90
$I_4$	5.54	7.44	6.97	5.55	6.37
$I_5$	6.78	7.93	7.73	6.60	7.26
Mean	5.28	6.13	5.71	5.46	5.63

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

(N Yadukumar and B Nagaraja)

An experiment was laid out in 1987 to find out suitable intercrops that can be grown in the interspace available during initial years of cashew plantations.

### PAR and Photosynthetic characteristics

The observations on light (PAR) received by the main crop three years after planting (one year after thinning of acacia and casuarina) in the plots of tree species showed that there was reduction in values in acacia (19.4%) and casuarina plots (40%). The light received under the canopy of subabul plants was to the extent of 56 per cent (Table 28).

Net photosynthetic rate and related parameters were measured in cashew under different combinations. Microclimatic variables when the measurements were made is given in Table 28. PN and  $g_s$  were maximum in cashew monocrop followed by cashew with subabul and casuarina (Table 30). Similarly, the PAR received by the cashew canopy under monocrop com-

pared to cashew grown with either casuarina or subabul was higher (Table 28). There was gradual decline in the PN over the years with the canopy of forest trees becoming denser. Cashew was most adversely affected when grown with acacia in respect to PN and is reflected in its growth performance as well (Table 29).

Data on transpiration rate (E) and WUE in cashew are presented in Table 31. E showed responses almost parallel to the PN values. Lowest WUE was observed in cashew grown with acacia and it declined further after three years.

Maximum competition for light was observed when acacia is grown as a mixed crop with cashew. There is need to periodically remove the forest trees at annual intervals to reduce this competition so that not only cashew performance can be improved but also the biomass can be utilized for fuel purposes or poles which can be used for various construction purposes. In

Table 28. Effect of mixed cropping on microclimate

Treatment	PAR ( $\mu\text{mol m}^{-2}\text{s}^{-1}$ )			% light received	Tair ( $^{\circ}\text{C}$ )			VPD (kpa)		
	2/89	1/90	2/91		2/89	1/90	2/91	2/89	1/90	2/91
Cashew monocrop	1510	938	1124	100.0	34.9	32.8	32.1	2.88	2.41	1.88
Cashew + Acacia	716	349	218	19.4	32.9	31.5	31.3	2.00	1.98	1.85
Cashew + Casuarina	1241	754	457	40.0	34.7	34.7	30.8	2.50	2.41	1.54
Cashew + Subabul	ND	810	629	56.0	ND	33.8	31.8	ND	2.57	1.73
SE	104	81	85		0.32	0.54	0.27	0.11	0.17	0.47

ND - Not determined

Table 29. Growth characters under different mixed cropping system

Treatment	Height (cm)		Girth (cm)		Canopy (cm)		Ground Coverages (%)	
	Main crop	Inter crop	Main crop	Inter crop	Main crop	Inter crop	Main crop	Inter crop
Cashew-Monocrop	270	-	30	-	340	-	14.15	-
Cashew+ Acacia	236	975	20	39	244	214	7.30	62.16
Cashew + Casuarina	256	840	23	26	287	211	10.02	59.23
Cashew + Subabul	249	541	26	21	261	202	8.40	54.37

Table 30. Changes in  $P_n$ ,  $g_s$  and intercellular  $CO_2$  in cashew grown with other forest tree species

Treatment	$P_n$ ( $\mu\text{mol CO}_2\text{m}^{-2}\text{s}^{-1}$ )			$g_s$ ( $\text{mol m}^{-2}\text{s}^{-1}$ )			Intercellular $CO_2$ (ppm)		
	2/89	1/90	2/91	2/89	1/90	2/91	2/89	1/90	2/91
Cashew monocrop	10.01	11.35	13.07	0.41	0.85	0.82	252	265	280
Cashew + Acacia	7.83	5.41	2.28	0.44	0.70	0.65	274	295	322
Cashew + Casuarina	10.59	9.11	7.72	0.50	1.12	0.81	259	283	294
Cashew + Subabul	ND	10.97	8.09	ND	0.82	0.86	ND	271	296
SE	0.58	0.94	0.94	0.02	0.08	0.03	3.0	5.3	6.3

ND - Not determined

Table 31. Changes in E and WUE in cashew grown with other forest species

Treatment	E ( $\text{mmol H}_2\text{O m}^{-2}\text{s}^{-1}$ )			WUE ( $\mu\text{mol CO}_2/\text{mmol H}_2\text{O}$ )		
	2/89	1/90	2/91	2/89	1/90	2/91
Cashew monocrop	9.42	10.33	9.60	1.07	1.10	1.20
Cashew+ Acacia	6.95	9.03	7.38	1.12	0.60	0.37
Cashew Casuarina	9.46	15.03	9.30	1.13	0.61	1.01
Cashew+ Subabul	ND	13.15	8.64	ND	0.85	0.93
Mean	8.72	11.77	8.34	1.10	0.78	0.96
SE	0.48	0.89	0.32	0.03	0.08	0.10

ND = Not determined

the fourth year of planting, the total biomass produced per tree as well as per hectare is presented in Table 32.

#### Soil moisture status

The soil moisture content determined in March (peak summer season) in different plots revealed that moisture content in pineapple and mucuna plots was more than control plot (Table 33). Further obser-

Table 33. Soil moisture content at three depths under different inter/mixed cropping systems

Treatment	Moisture content (%)			Mean
	Depth (cm)			
	0-25	25-50	50-75	
Cashew+pineapple	10.47	9.63	14.51	11.53
Cashew+casuarina	5.55	7.66	6.85	6.59
Cashew+subabul	8.56	10.56	10.23	9.78
Cashew+acacia	8.35	9.16	8.17	8.56
Cashew+mucuna	9.58	11.51	13.36	11.48
Cashew alone	7.51	7.94	9.82	8.42

vations revealed that the moisture content was minimum in plot with tree species. This was particularly evident in casuarina plot. Exhaustion of moisture by tree species during the peak summer season adversely affected the main crop. The moisture content extracted by the casuarina and acacia at deeper layers was evident with reduction in moisture content at 50-75 cm depth (Table 33).

#### Yield

Data on initial yield showed that maximum yield of cashewnuts (4.51 kg/plot) was realised from pineapple plot (6 plants/plot) which was 77 per cent increase over control plot. In plots with tree species as intercrops the yield was less and minimum yield of 0.4 kg/plot was realised

Table 32. Biomass produced in the fourth year of planting

Tree	Dry wt./ tree (t)	Dry wt. (t/ha)	No. of poles of 5m length/ha
Casuarina	0.05	1.25	575
Acacia	0.04	1.04	575

from cashew and acacia combination (84% reduction) (Table 34).

Table 34. Initial yield of cashew under different cropping system (three years after planting)

Treatment	Nut yield of 6 plants	
	Kg/plot	% control
Cashew + sweet potato	2.31	90.9
Cashew + cucumber	1.75	68.9
Cashew + pineapple	4.51	177.5
Cashew + guava	2.98	117.3
Cashew + mucuna	2.06	81.1
Cashew + casuarina	0.85	33.5
Cashew + subabul	1.35	53.1
Cashew + acacia	0.40	15.7
Cashew alone	2.54	-
CD	0.94	-

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

(N Yadukumar)

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

Design : Split plot      Replication: 3

**Treatments**

Main plot	Sub-plot
1. 5 x 5m square	1. Pruned
2. 6 x 6m square	2. Unpruned
3. 8 x 8m square	
4. 5 x 4m hedge	
5. 6.5 x 4m hedge	
6. 8 x 4m hedge	

Existing forest tree species in the plot were cleared during the season. While removing the forest trees few grafts (10%) have dried. The gap filling with two year old grafts will be done during the next season (1992). Initial shape pruning was done during the year.

**Agr. VI : Development of suitable cashew based cropping systems**

(N Yadukumar and B Nagaraja)

Two trials with fruit crops and forest tree species as inter/mixed crops were laid out in 1990 with three replications, to develop suitable cashew based cropping system. The fruit crops include ber, kokam, pomegranate, custard apple and gooseberry (aonla). The forest tree species include acacia, subabul, bamboo, alanthus and casuarina. High density planting of cashew (5 x 5m) and control (10 x 5m) treatments have also been included in the above trials.

**Cashew with fruit crops**

During the period (second year of planting) the following plants have been gap filled. The gaps were due to porcupine and wild boar attack (Ber -4; Kokam-6; Pomegranate-6; Sitaphal-6; Gooseberry-15 and cashew -156). In spite of regular plant protection measures mortality of custard apple (sitaphal) upto 20 per cent was observed. The gap filling will be taken up during the next season.

### Cashew with forest tree species

Based on the decision of the Research Council, the spacing of casuarina, acacia and ailanthus has been changed. The existing acacia plants have been shifted and planted at 3.5 meters away from the row of cashew grafts. The population of acacia plants have been increased from 24 to 72 by

interplanting within the acacia rows. The existing casuarina plants adjacent to the cashew plants row have been shifted to 3.5 m. away from the cashew rows. In case of ailanthus six more rows in each plot have been planted to increase the population from 21 to 57 (57 plants/plot).

### Agri. VII : Comparative efficacy of slow release nitrogenous fertiliser for cashew

(N Yadukumar)

This project was started with the objective of studying the effect of slow release nitrogenous fertilizers on crop yield. The trial was laid out at Kemminje in 1990

by planting grafts of M 44/3 at 7 m. spacing. The treatments will be imposed three years after planting.

### Phy. III : High density planting of cashew

(N Yadukumar)

An experiment was initiated in 1982 to assess the effect of different plant densities on growth and yield. Studies conducted during 1990 and 91 (8 and 9 years after planting) revealed that the closer planting reduced the net photosynthesis ( $P_n$ ). Transpiration (E) showed similar but non-significant trend between the plant densities. The  $P_n$ , gs and E had linear relationships. In cashew, it is apparent that competition for irradiance is a limiting factor and any cropping system should aim at optimising this for higher productivity (Table 35).

### Yield

Observations on yield showed that

maintaining the plant density of 625 trees/ha continued to give higher yield (619 kg/ha) than other treatments. Increased yield (594 and 374 kg/ha) was observed two years after thinning in T4 and T5 treatments, whose present population is 555 and 625 trees/ha. Thinning has helped in obtaining the increased yield. These treatment in the first year after thinning had given only 305 and 256 kg/ha respectively. Steady increase in yield is observed in T1 and T2 treatments whose densities are 156 and 278 trees/ha respectively (Table 36). The cumulative yield data upto 9 years after planting indicated that maintaining density of 625 trees/ha (T-3) by pruning of overlapping branches in 8 and 9 years after planting continued to

Table 35. Changes in  $P_n$  and other parameters in cashew, as affected by different densities of planting

Treatment	Density (trees/ha)	$P_n$ ( $\mu\text{mol m}^{-2}\text{s}^{-1}$ )		$g_s$ ( $\text{Mmol m}^{-2}\text{s}^{-1}$ )		CI ( $\text{CM}^2\text{m}^{-2}$ )		E ( $\mu\text{mol m}^{-2}\text{s}^{-1}$ )	
		1990	1991	1990	1991	1990	1991	1990	1991
T <sub>1</sub>	156	12.07	9.25	1.14	0.54	279	264	15.5	13.02
T <sub>2</sub>	278	10.15	9.78	0.79	0.60	266	283	10.85	12.72
T <sub>3</sub>	625	6.01	6.27	0.90	0.43	292	295	10.62	9.72
T <sub>4</sub>	1111 upto 7 yrs and 555 after thinning	12.11	6.50	0.84	0.76	272	297	11.85	12.67
T <sub>5</sub>	2500 upto 7 yrs and 625 after thinning	10.26	5.71	0.77	0.69	276	293	11.22	12.02
LSD		T -2.05** Yr -1.95*		T -0.24 (NS) Yr -0.18**		T -14.97 Yr -5.89		Significant at P=0.05	

Table 36. Yield of nuts as affected by spacing (8 and 9 years after planting)

Treatment	Density (trees/ha)	Yield (kg/ha)		Cumulative yield (upto 9 years after planting) (kg)
		1990	1991	
T1	156	240	311	1093
T2	278	297	469	1415
T3	625	468	619	2762
T4	111 upto 7 yrs and 555 after thinning	305	594	2404
T5	2500 upto 7 yrs and 625 after thinning	256	374	2279

yield maximum (2762 kg/ha) as compared to other treatments (Table 36). From the above data it can be inferred that maximum yield/unit area can be realised by maintain-

ing the population density of 625 trees/ha upto 9 years after planting through pruning of overlapping and weak branches.

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

(M. Gangadhara Nayak)

Pruning, the removal of unwanted plant parts is little known in cashew. Based on the results from the concluded project on the effect of time and severity of pruning in cashew, a trial was initiated on a large scale during 1988 at Experimental station, Shantigodu, to demonstrate the beneficial effect of pruning in cashew.

Among the sixty trees (VTII-174) planted during 1976, 30 were pruned and the remaining 30 served as control. Pruning was done during the second week of August by heading back the leader shoots to two thirds of original length and upto 50 per cent of total leader shoots in a tree. The

dried branches, twigs and the water sprouts were removed during the pruning operation.

Data on the mean yield for three years is presented in Table 37. Before initiating the trial, the three years mean yield of trees selected for pruning was 3.65 kg while that of control was 3.08 kg. Higher yield (5.88 kg) recorded after the first year of pruning over the control trees (2.61 kg) justified the need for pruning. The yield of the pruned trees during the subsequent years was not very much higher than the control trees. The pruned trees, however, continued to yield more than unpruned trees.

Table 37. Mean yield (kg/tree) of pruned and unpruned trees

	Yield (kg/tree)	
	Pruned	Unpruned
Three years mean before imposing treatment	3.65	3.08
After imposing treatment		
1988-89	5.88	2.61
1989-90	2.32	1.17
1990-91	3.93	1.36
Cumulative yield	12.13	5.14
Mean cumulative yield	4.04	1.71

(M Gangadhara Nayak and KRM Swamy)

Graft production in cashew is hampered during flushing and flowering period because of limited availability of scion sticks for grafting. During drier months, reduced graft success is noticed because of high temperature and low humidity. This project was initiated with an objective of finding out the possibility of enhancing the production of successful graft during off-season especially flushing period and drier months.

#### Soft wood grafting with green scion sticks :

Based on the results obtained earlier during 1990-91 scion sticks of 45 and 60 days were only used for the study. Graft success with 15 and 30 day old scion sticks was very poor. Softwood grafts with 45 and 60 day old scion sticks were prepared during October, November, December and January and the mean graft success was recorded (Table 38). The mean graft success with 45 days old scion sticks was 46.4 per cent, while that of 60 day old scion sticks was

60.2 per cent. Softwood grafts produced on commercial scale in the month of December 1991 (3840) using 60 day old scion sticks gave a graft success of 59.4 per cent (1958). Thus, off season graft production can be successfully carried out using green scion sticks of above 60 days during flushing and flowering period.

#### Softwood graft production with the use of low cost humidity chambers :

Studies were continued with the use of low-cost humidity chambers during 1991-92 to find out the possibility of increasing the graft success during drier months. The low-cost humidity chamber consists of a rectangular wooden frame of length (140 cm), width (100 cm) and height (75 cm) covered with a polythene sheet. A layer of bricks of above measurements was kept as basement for the chamber. Inside the structure a layer of sand was spread over a black polythene sheet. The sand bed was moistened and the grafts were arranged on

Table 38. Graft success with green scion sticks

Month of grafting	No. of grafts prepared	Graft success			
		45 day old scion sticks		60 day old scion sticks	
		No. of successful grafts	% success	No. of successful grafts	% success
Oct 1991	150	84	56.0	99	66.0
Nov 1991	100	40	40.0	50	50.0
Dec 1991	100	50	50.0	67	67.0
Jan 1992	100	35	35.0	55	55.0
Total	450	209	46.4	271	60.2

the sand bed. Then the wooden frame covered with polythene sheet was placed over the bricks and retained for 15 days. Later, the grafts were shifted to open place in the nursery. A set of grafts prepared by covering individual grafts with cap (normal

method) was used as control. The grafting was carried out during the drier months (January to May) and the results are presented in Table 39. The per cent graft success both under low cost humidity chamber and normal method was similar.

Table 39. Per cent graft success under low-cost humidity chamber

Month	No. of grafts prepared	Low cost humidity chamber		Normal method	
		No. of successful grafts	Per cent success	No. of successful grafts	Per cent success
Jan	100	70	70.0	68	68.0
Feb	100	69	69.0	63	63.0
Mar	100	72	72.0	81	81.0
Apr	100	73	73.0	72	72.0
May	50	40	80.0	42	84.0
Total	450	324	72.0	326	72.4

#### Hort. V : Root stock studies in cashew

(M Gangadhara Nayak and KRM Swamy)

Studies on rootstock were started with an objective of screening cashew types for dwarfing character at nursery stage on the basis of morphological and anatomical characters. Initial observations on different cashew types have indicated that the morphological and anatomical characters of seedlings do not serve as an index for selecting the dwarfing root stock at nursery stage. As such, a field trial will be laid out with softwood grafts of NRCC selection-1 on rootstock seedlings raised from the seednuts collected from vigorous and less vigorous types. The seednut from vigorous and less vigorous trees identified at Vittal and Shanthigodu were collected and sown in polythene bags during September 1991 for raising the seedlings. Softwood grafts of

NRCC Selection-1 were prepared with these seedlings as root stocks.

Observations on nut weight, germination percentage height of seedling, number of leaves and internodal length were recorded (Table 40). The height of the seedlings was directly proportional to the weight of the nut. The nuts with higher weight resulted in vigorous seedlings when germinated. Less vigorous seedlings exhibited minimum internodal length compared to vigorous types. The grafts of NRCC Selection-1 produced with these seedlings as rootstocks exhibited differences with respect to height for initial three months (Table 41). The grafts are being maintained for further observations.

Table 40. Observations on five months old root stock seedlings

Rootstock	Mean nut weight (g)	Germination %	Mean height (cm)	Mean no. of leaves	Mean internodal length (mm)
<b>Vigorous types</b>					
VTH-174	7.0	96.0	34.6	14	14.2
S-34/7	7.1	55.3	31.9	14	20.0
S-34/8	7.6	57.3	37.0	17	15.0
<b>Less vigorous types</b>					
S-11/1	4.3	45.3	33.9	18	15.0
S-11/2	4.6	78.0	18.7	15	10.0
S-12/1	5.1	78.0	26.5	17	13.8
VTH 762/2	3.5	72.3	16.9	13	11.2
VTH-762/4	3.5	88.0	18.2	15	9.4

Table 41. Mean height of 3 month old grafts of NRCC-Selection - 1.

Root stock	Mean height (cm)
VTH 174	41.8
S-34/7	31.8
S-34/8	30.6
S-11/1	29.0
S-11/2	30.8
S-12/1	27.0
VTH 762/2	26.7
VTH 762/4	24.3

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

(KRM Swamy and N Bakthavatsalam - upto 28-11-1991)

This project was initiated during June 1990 to compare the economics of top working with fresh planting of cashew (re-planting). This experiment was started during June 1990. Thirty cashew trees of 14 years old which were headed back during June 1990, were top worked with VTH 30/4

by adopting softwood grafting technique during September/October 1990. Adjacent to this plot, 30 cashew trees were completely removed and replanting was undertaken by planting one year old cashew grafts of VTH 30/4 during August, 1990. Out of 30 top worked trees, 11 trees died due to

stem borer infestation (36.7%) during 1990-91. During the year under report, the height and girth of grafted shoots of the top worked trees were recorded after 15 months of grafting. The height of shoots ranged from 160.0-310.0 cm with a mean of 254.7 cm and the girth ranged from 12.5-23.0 cm with a

mean of 16.9 cm (Table 42). The growth of grafted shoots on top worked trees was double compared to replanted grafts. The cost of establishment and maintenance of 0.2 ha top worked plot and 0.2 ha replanted plot during the first two years was Rs. 2086 and Rs. 1150 respectively (Table 43).

Table 42. Height and girth of top worked shoots and replanted cashew grafts after 15 months.

		Top worked plot	Replanted plot
Height of shoots/ grafts (cm) :	Min	160.0	70.0
	Max	310.0	110.0
	Mean	254.7	82.5
Girth of shoots/ grafts (cm) :	Min	12.5	6.0
	Max	23.0	10.0
	Mean	16.9	7.8

Table 43. Cost of establishment and maintenance of 0.2 ha top worked plot and replanted plot during the first two years.

Year	Amount spent (Rs.)	
	Top worked plot	Replanted plot
First year	1241	620
Second year	845	530
Total	2086	1150

## CROP PROTECTION

Results from a large plot prophylactic control trial on stem borer have indicated that neemark protected trees against stem borer for four months. Lowest infestation (2.8%) was noticed after six months in trees treated with neemark, neem oil and BHC. Trees at early stage of infestation recovered when treated with ethylene dibromide, kerosene and aluminium phosphide. Results from studies on *Baculixia bassiana* have indicated that direct spraying was most effective with mortality of 60 percent. Studies on light trap are not encouraging. Studies on chemical control trials with dust formulations have revealed that application of carbaryl five per cent dust is most effective although the cost is higher compared to quinophos and endosulfan. Carbaryl and monocrotophos have higher residual toxicity followed by dimethoate and decamethrin which is reflected in the survival of nymphs of tea mosquito. Survey on egg parasitoids of tea mosquito from three locations (Mane, Pane Mangalore and Konaje) has revealed the occurrence of two species of parasitoids (*Telenomus* sp and *chaetosyricha* sp). *Telenomus* sp was found to be dominant in all the locations. A total of 23 species of parasitoid hymenopterans were collected and got identified by International Institute of Entomology, London. Laboratory studies on culturing of egg parasitoid (*Telenomus* sp) are being continued. For the control of wild silkworm, noticed in the districts of Kannur and Kasaragod Districts of Kerala, an integrated control measure such as hand picking and destruction, collection and destruction of pupae and need based spraying with 0.05% endosulfan or monocrotophos or 0.1% carbaryl has been suggested.

## Ent. V : Developing integrated pest management package against cashew stem and root borer.

(N Bakhavatsalam (Up to 28-11-1991) and P Shivarama Bhat  
From 1-2-1992)

The stem and root borer *Plocaederus ferrugineus* (Coleoptera: Cerambycidae) is a major pest of cashew. The attacked trees do not survive in severe cases. In order to develop an integrated pest management package against it, a project was initiated including various components of pest management. During the year work on prophylactic, curative, biological and mechanical methods were carried out.

### Large plot prophylactic control trial

The large plot trial was laid out at Shanthigodu in May, 1991. A block of 60-75 trees with atleast 10 per cent infestation was selected for each treatment. Results from different treatments applied as swab to a height of one metre from the base of the tree trunk is summarised in Table 44. Observations on the incidence of stem borer in treated trees were taken at monthly in-

terval for six months. All the treatments protected the trees for at least two months. Neemark treated trees showed no stem borer incidence for about four months. After six months of treatment, lowest infestation (2.8%) was noticed in trees treated with neemark, neem oil and BHC. The trial will be repeated by giving treatments at three months interval.

### Efficacy of fumigants in the revival of trees :

The fumigants were applied as curative control measure for stem borer infested trees at early, middle and advanced stages of infestation at CPCRI, Regional Station, Vittal. Trees at early stage of infestation showed recovery when treated with ethylene dibromide (EDB), kerosene and aluminium phosphide (Table 45). The quantity of fumigants used and the average cost

Table 44. Stem and root borer infestation in large plot prophylactic control trial.

Treatment	Per cent trees infested at					Cost of treatment (Rs)
	30 DAT	60 DAT	90 DAT	120 DAT	180 DAT	
Coal tar + Diesel (1:2)	0	0	0	9.4	15.6	2.99
Neem oil (6%)	0	0	0	1.4	2.8	1.88
Neem mark (0.4%)	0	0	0	0	2.8	0.45
Aldrin (0.2%)	0	0	1.4	2.8	4.2	1.14
BHC (2%)	0	0	0	1.4	2.8	0.59
Control	0	4.6	7.7	7.7	9.2	-

DAT = Days after treatment

Table 45. Recovery, dosage and cost involved for curative control of stem borer at early stage of infestation

Treatment	No. of trees treated	No. of trees recovered	Dosage		Average cost (Rs)
			Lower	Higher	
EDB	2	2	3 ml	18 ml	2.99
Petrol	2	0	5 ml	50 ml	0.42
Chloroform	4	1	10 ml	45 ml	2.47
Kerosene	5	4	5 ml	30 ml	0.24
Aluminium Phosphide	3	2	6 g	21 g	2.28

is also presented in the table. The cost was maximum for EDB and minimum for kerosene. Kerosene is safer and available easily. Similar treatments were tried on trees at middle and advanced stages of infestation. All the treated trees died.

#### Testing the efficacy of *Beauveria bassiana* :

Tests were carried out with entomofungal pathogen *B. bassiana* under laboratory conditions. Three methods of application tried are (i) direct spraying of spore suspension on the grub (ii) soaking the bark pieces in spore suspension and allowing the grubs to feed and (iii) mixing the fungal suspension in saw dust and allowing the grubs to feed. Among these

methods, direct spraying recorded maximum mortality upto 60 per cent, whereas the mortality was 10-20 per cent in others. The infected grubs showed typical fungal disease symptoms with mycelial growth throughout the body.

#### Survey on natural enemies :

Parasites or predators were not recorded in the areas surveyed at Vittal and Shanthigodu.

#### Light trap studies :

Studies on light trap are not encouraging. Only one female adult was trapped in April. Cashewnut shell liquid (CNSL), when placed along with luminescent light, did not attract the adults.

### Ent. VII : Chemical control experiments against tea mosquito bug *Helopeltis antonii*

(N Bakthavatsalam (Upto 28-11-1991) P Shivarama Bhat  
(From 1-2-1992) and D Sundararaju)

The objectives of this project are to work out suitable dust formulation for the control of tea mosquito bug especially in the plantations where there is scarcity of water. It is also envisaged to work out ovicidal and residual action of certain rec-

ommended insecticides against this pest.

#### Chemical control experiments with dust formulations :

An experiment was laid out in KCDL plantations at Aryapur (5 KM away from

Puttur). The dusts tested were carbaryl 5 per cent and quinalphos 1.5 per cent along with endosulfan 0.05 per cent spray as treated control. The dusting was done on entire tree canopy between January and February 1992 which coincided with flowering and fruiting stages. Shoot damage in an area of 0.5 m x 0.5 m on all the four

directions were recorded after 10, 20 and 30 days of each dusting (Table 46). Application of Carbaryl 5 percent dust was found to be effective in checking the incidence of tea mosquito. The per cent shoots infested was 5.54 in this treatment after 30 days of second dusting. Quinalphos 1.5 per cent dust was not found effective in checking

Table 46. Efficacy of dust formulations against tea mosquito bug at Aryapatti in 1991-92.

Time of observation	Quinalphos	Carbaryl	Endosulfan	Control	CD at 5%
<b>Pre treatment</b>					
Shoots infested (%) <sup>*</sup>	3.77	13.23	30.22	11.77	NS
Damage score <sup>**</sup>	0.64	0.46	1.10	0.33	NS
<b>I dusting :</b>					
10 days :					
Shoots infested (%)	7.44	6.13	18.61	20.43	NS
Damage score	0.17	0.16	0.54	0.64	NS
20 days :					
Shoots infested (%)	12.61	10.70	31.11	26.11	NS
Damage score	0.34	0.51	0.75	0.81	NS
30 days :					
Shoots infested (%)	17.00	15.51	25.26	32.56	NS
Damage score	0.49	0.45	0.68	0.55	NS
<b>II dusting :</b>					
10 days :					
Shoots infested (%)	23.06	4.44	33.45	34.96	15.26
Damage score	0.70	0.14	0.92	1.05	0.20
20 days :					
Shoots infested (%)	21.86	5.10	33.90	33.15	14.52
Damage score	0.73	0.15	1.06	0.97	0.19
30 days :					
Shoots infested (%)	22.47	5.63	35.68	36.85	15.44
Damage score	0.81	0.18	1.00	1.12	0.25

NS - Non significant.

\* Data analysed after angular transformation.

\*\* Damage score in (1-4) scale analysed after square root transformation.

insect multiplication with 22.47 per cent shoot infestation at that stage. The damage score was also lowest (0.18) in carbaryl, followed by quinalphos (0.81) at this stage and it was 1.00 for treated control and 1.12 for untreated control. Statistical analysis showed significant difference between different treatments.

Economics of the different treatments tried, is presented in Table 47. The cost involved in carbaryl treatment is higher compared to quinalphos and endosulfan treatments. In case of endosulfan, additional labour was required for carrying water from distant place for preparing insecticide solution. Hence, the labour cost for the endosulfan treatment was higher.

#### Residual action of recommended insecticides :

The cashew trees at flushing stage were sprayed with recommended insecticides against tea mosquito bug. Fresh shoots were collected after 3, 7 and 15 days of treatment and adults were allowed to feed on these shoots in cages for 24 hr. Six adults were released into each cage and the experiment was replicated thrice. Adult survival and damage on shoot were re-

corded and analysed after square root transformation. The results are presented in Tables 48 and 49.

Carbaryl and monocrotophos were found to have higher residual toxicity followed by dimethoate and decamethrin. The residual effect remained for longer period both in case of carbaryl and monocrotophos. As far as, shoot damage was concerned, least damage for a prolonged period was recorded in carbaryl treatment.

#### Ovicidal action of recommended insecticides :

The tender shoots of flushing cashew trees were covered with cages and gravid females were released inside for oviposition. After 24 hr, the cages were removed and insecticides at recommended dosage were sprayed on these tender shoots. The shoots were brought to laboratory and observed for egg hatching. Survival of nymphs upto 72 hr after egg hatching was also observed. The treatments had no effect on egg hatching but survival of nymphs was greatly affected in case of carbaryl, monocrotophos and phosalone due to high residual action (Table 50).

Table 47. Economics of different insecticides tested against tea mosquito bug. (Rs/ha)

Treatment	Quantity/ Treatment	Cost of insecticide (Rs)	Labour cost (Rs)	Total cost (Rs)
Quinalphos	34 kg	840	150	990
Carbaryl	26 kg	920	150	1070
Endosulfan	1.1 L	200	450	650

Table 48. Residual action of recommended insecticides on survival of adults of tea mosquito bug

Treatment	No. of adults survived for 24 hr in shoots collected after			Mean
	3 days	7 days	15 days	
Endosulfan 0.05%	5.00 c A	5.67 c A	5.67 a A	5.44 c
Quinalphos 0.05%	4.33 c A	5.33 c A	5.00 a A	4.89 c
Phosalone 0.07%	4.33 c A	5.67 c A	5.33 a A	5.11 c
Carbaryl 0.1%	0.00 x A	0.33 a A	5.33 a B	1.89 x
Decamethrin 0.0028%	1.33 b A	3.67 bc B	5.00 a B	3.33 b
Monocrotophos 0.05%	0.00 x A	1.00 a A	5.33 a B	2.11 x
Dimethoate 0.05%	1.67 b A	3.00 ab A	6.00 a B	3.56 b
Methyl parathion 0.05%	4.67 c A	5.00 c A	5.33 a A	5.00 c
Control	6.00 c A	6.00 c A	6.00 a A	6.00 c
Mean	3.04 A	3.96 B	5.44 C	

- Treatment, period and interactions were significant at 1% level.

- Mean followed by common lower case letter in each column is not significantly different at 5% DMRT (Duncan's Multiple Range Test)

- Mean followed by common capital letter in each row is not significantly different at 5% DMRT.

**Table 49.** Residual action of recommended insecticides on damage to shoots by adults of tea mosquito bug

Treatment	Damage score (0-4 scale) for 24 hr. feeding in shoots collected after			Mean
	3 days	7 days	15 days	
Endosulfan 0.05%	3.00 f A	3.17 c A	2.89 b A	3.01 f
Quinalphos 0.05%	2.67 ef AB	2.83 c B	2.33 a A	2.61 e
Phosalone 0.07%	2.33 c A	3.00 c B	2.67 b B	2.67 e
Carbaryl 0.1%	0.33 a A	0.33 a B	2.22 a C	1.13 a
Decamethrin 0.0028%	1.67 d A	2.67 c B	2.55 ab B	2.30 d
Monocrotophos 0.05%	0.67 b A	1.00 a B	2.67 ab C	1.45 b
Dimethoate 0.05%	1.00 c A	1.67 b B	2.55 ab C	1.74 c
Methyl parathion 0.05%	1.67 d A	2.83 c B	2.67 ab B	2.39 d
Control	3.00 f A	3.00 c A	2.78 b A	2.92 f
Mean	1.82 A	2.33 B	2.59 C	

- Treatment, period and interactions were significant at 1% level.
- Mean followed by common lower case letter in each column is not significantly different at 5% DMRT.
- Mean followed by common capital letter in each row is not significantly different at 5% DMRT.

**Table 50.** Ovicidal action of recommended insecticides against tea mosquito bug

Treatment	Per cent eggs hatched	Per cent nymphs survived after 72 hr
Carbaryl 0.1%	100	0.0 a
Monocrotophos 0.05%	100	0.0 a
Phosalone 0.07%	100	4.4 a
Endosulfan 0.05%	100	11.4 b
Control	100	48.2 c

Values followed by common letter are not significant at 5% DMRT.

## Ent. VI : Biological control of tea mosquito bug and other sucking pests of cashew.

(D Sundararaju)

The project was initiated with an objective of studying the various aspects of biological control of tea mosquito and other sucking pests of cashew.

### Survey on egg parasitoids of tea mosquito bug on cashew and cacao :

The eggs laid by tea mosquito bug (TMB) on shoot, leaf petioles and rachis of panicle from untreated cashew trees were collected periodically from three locations (Mane, Pane Mangalore and Konaje). The plant parts containing the eggs were dipped in 0.1 per cent carbendazim solution for five min. and dried and finally placed in a

small transparent plastic container (250 ml capacity) having screw cap with a small transparent glass tube containing minute droplets of pure honey. The whole plastic container was covered with black chart paper except the glass tube so as to facilitate for easy collection of adult parasitoids inside the glass tube. By this method, maximum number of adult parasitoids could be collected and they were subsequently used for other biological studies. All the egg samples were observed over a period of 75 days and the number of parasitoids emerged out were recorded (Table 51). During this year also, emergence of same

Table 51. Survey on primary egg parasitoids of tea mosquito bug

Period		Locations					
		Mane		Panemungalore		Konaje	
		TE*	PE*	TE	PE	TE	PE
Feb	91	16	7 (5)	75	8 (2)	39	2 (1)
Mar	91	12	7 (4)	60	3 (1)	57	7 (2)
Apr	91	11	1 (1)	16	1 (1)	22	5
May	91	10	0	37	4 (2)	59	20 (6)
Jun	91	8	2	13	2	NR	
Jul	91	0	0	125	19 (1)	55	18
Aug	91	7	2	81	7	13	1
Sept	91	2	0	54	9	31	1
Oct	91	2	0	44	14	6	1
Nov	91	12	2 (1)	114	9	92	23
Dec	91	17	2	190	14 (1)	112	14 (1)
Jan	92	9	3	139	8 (1)	140	19
Total		106	26 (11)	946	98 (9)	626	111 (10)
Parasitism%		24.5			10.43		17.7

T.E. - Total number of eggs of tea mosquito bug.

P.E. - No. of parasitoids emerged out (*Telenomus* sp. and *Chaetostricha* sp.)

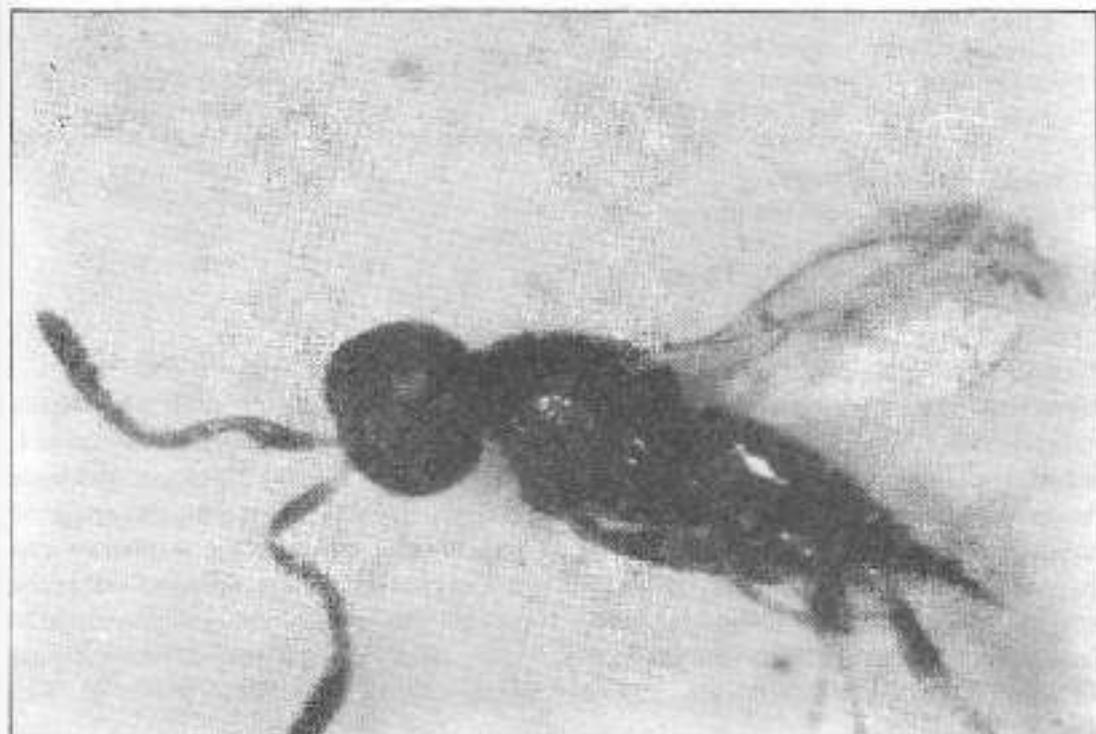
Figures in parantheses indicate the population of *Chaetostricha*-sp. only

N.R. Not recorded.

two species of parasitoids (*Telenomus* sp. and *Chaetostricha* sp.) was observed. Among these two, *Telenomus* sp. was found to be dominant in all locations.

The extent of parasitization was also

observed in a cashew plot at NRCC campus Kemminje which had received three rounds of spray. The occurrence of both the species of above mentioned parasitoids have also been noticed at this locality (Table 52). The egg samples of TMB collected from



*Telenomus* sp (Fam Scelionidae) - An egg parasitoid of tea mosquito.



*Chaetostricha* sp (Fam. Trichogrammatidae) - An egg parasitoid of tea mosquito

cacao pods at Vittal have not revealed the existence of any parasitoids.

#### **Survey on other natural enemies of tea mosquito bug and other sucking pests :**

In order to confirm the existence of any nymphal/adult endoparasitoids of TMB, both nymphs and adults of TMB were observed periodically. Since no parasitoids had emerged out from the samples collected, attempts were made to collect and

**Table 52.** Extent of parasitisation by egg parasitoids\* of tea mosquito bug in the monocotophos (0.05%) treated plots at Kemminje

Collection date	Total no. of eggs collected	Date on which first and last parasitoid emerged out	No. of parasitoids emerged out	% parasitisation
25-12-91*	99	14 Jan./30 Jan.	(0)	9.1
3-1-92*	114	20 Jan./26 Feb.	25 (3)	21.9
4-1-92**	121	10 Jan./25 Feb.	34	28.1
6-1-92**	70	30 Jan./15 Feb.	12 (2)	17.1
10-1-92**	117	18 Jan./2 Mar.	33 (1)	28.2
Total	521		113 (15)	21.7

\**Telenomus* sp and *Chaetostricha* sp.

Figures in parentheses indicate only *Chaetostricha* sp.

\* 20-30 days after second spray

\*\* After third spray (sprayed on 3-1-92)

identify all the available adult parasitic hymenopterans visiting cashew extra floral nectaries, so as to find out the nymphal/adult endoparasitoid (*Leiophron helopeltidis*) already identified on TMB. A total of 23 species of parasitoid hymenopterans were collected and got identified by International Institute of Entomology, London, (Table 53). The identified list of parasitoids indicated the absence of *Leiophron helopeltidis*, the nymphal parasitoid of TMB. The existence of already recorded parasitoid of TMB (*Erythmelus helopeltidis*) has been confirmed in this survey. Two species of spiders as predators (*Oxyopes* sp and *Plexippus* sp.) of TMB were also collected. The ectoparasitic mite recorded on adult and nymph of TMB has been identified as *Bochiartia* sp. No other additional natural enemies were observed from other sucking pests (aphids and mealy bugs) of cashew.

**Laboratory studies on the life history and culturing of egg parasitoid (*Telenomus***

**sp) of Tea Mosquito bug :**

The longevity of adult parasitoids ranged from 2-9 days (mean 6.1 days) and 1-8 days (mean 2 days) for female and male respectively. One day old female parasitoid was noticed inserting the ovipositor into the eggs of TMB. It was able to locate the eggs of TMB within a minimum period of 30 min. and it initially inserted the ovipositor twice or thrice for a short period of 5-10 min. and finally inserted the ovipositor comparatively for a longer period of 20-40 min. Further, it was able to insert the ovipositor into all the 1-8 days old eggs of TMB. Maximum of eight adults had emerged out from TMB eggs which were parasitized by a single parasitoid.

For three months, studies on culturing of *Telenomus* sp was undertaken. A total of 40 eggs of TMB were exposed for parasitisation during August. Though oviposition by parasitoid was observed, only three parasitoids could emerge after fortyfifth day of parasitisation. When the

Table 53. List of parasitic hymenopterans visiting extra floral nectaries of cashew.

Sl. No.	Name	Family	Host Range
1.	<i>Androcephalus</i> sp.	Chalcididae	Parasite on Lepidoptera
2.	<i>Brachymeria</i> sp.	Chalcididae	Pupal parasites of lepidoptera
3.	<i>Epitranus erythrogaster</i> Cameron	Chalcididae	Parasitic on Lepidoptera
4.	<i>Elasmus</i> sp.	Elasmidae	Parasitic/Hyperparasitic on Lepidoptera.
5.	<i>Comperiella</i> sp.	Encyrtidae	Endoparasitoids of diaspid scale insects.
6.	<i>Lamennisia ambigua</i> Noes	Encyrtidae	Cosmopolitan parasitic species
7.	<i>Lamennisia</i> sp.	Encyrtidae	—
8.	<i>Paralitomasi</i> sp.	Encyrtidae	Polyembryonid parasitoids of Lepidoptera.
9.	<i>Copidosoma</i> sp near <i>bignanicum</i> (Mercet)	Encyrtidae	Polyembryonid parasitoids of Lepidoptera.
**10.	<i>Pediobius</i> sp.	Eulophidae	Hyper parasitoid of Lepidoptera
11.	<i>Platylabus</i> sp.	Eulophidae	Gregarious external parasitoids of Lepidopterous larvae.
*12.	<i>Sympiesis</i> sp.	Eulophidae	Solitary or gregarious external parasitoids of lepidopterous larvae.
13.	<i>Tetrastichus</i> spp. (Three species)	Eulophidae	Parasites/hyper parasites of Lepidoptera, Coleoptera and Diptera.
14.	<i>Bracon hebetor</i>	Braconidae	Parasite on Lepidoptera
15.	<i>Eurytoma</i> sp.	Eurytomidae	Parasites of insects.
16.	<i>Podagrion</i> sp.	Torymidae	Parasites in Onthecae of mantids
*17.	<i>Telenomus</i> sp.	Scelionidae	Endoparasitoids in eggs of miridae.
18.	<i>Erythroneura helophelidis</i> Cahon.	Mymaridae	Primary egg parasitoid of Miridae.
*19.	<i>Aphanogmus marmoratus</i> (Ashmead)	Ceraphronidae	Hyperparasitoid on Braconids
20.	<i>Aphanogmus</i> sp.	Ceraphronidae	Not known
*21.	<i>Pristomerus</i> sp.		Parasite on Lepidoptera.
22.	<i>Lipotriches</i> sp.	Halticidae	Not known
23.	? <i>Goryphus</i> sp.	Braconidae	Not known

Simultaneously recorded on pests\* of cashew and primary parasitoid\*\* of cashew pests.

remaining parasitised eggs were examined under dissection microscope on seventy-fifth day, fourteen unemerged dead adults were found inside the parasitised eggs of TMB. The poor emergence of parasitoids may be due to desiccation of plant parts containing parasitised eggs of TMB as well as to excessive fungal growth on the plant parts.

In the subsequent studies when the

parasitised eggs of TMB were kept under damp condition with 0.1 per cent carbendazim the fungal growth could not be completely checked (Table 54). The emergence of parasitoids however was observed comparatively more in number as well as in a short period of 17-20 days.

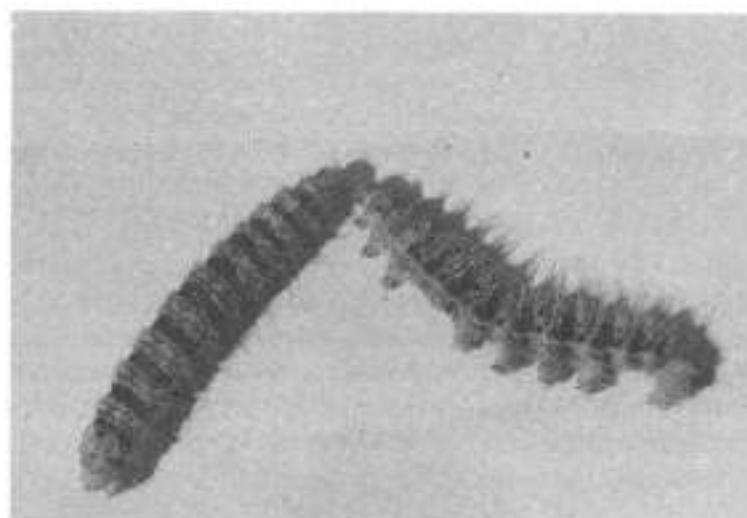
#### Incidence of wild Silk Worm:

During the year, outbreak of silkworm, *Cricula trifenestrata* (Lepidoptera :

Saturridae) has been noticed in Kannur and Kasaragod districts of Kerala. It is a stout reddish brown hairy caterpillar found in swarms on cashew, wild silk cotton, mango and on several species of forest trees of this region during September - November months and causes extensive damage by complete defoliation of trees.

For the control of this pest the following integrated approaches are suggested.

- (i) Hand picking and destruction of caterpillar
- (ii) Collection of pupae and destruction during summer months.
- (iii) Need based spraying if it occurs on young flushes with 0.05 per cent endosulfan or monocrotophos or 0.1 percent carbaryl.



Wild silk worm infesting cashew in Kerala

Table 54. Culturing of egg parasitoid (*Telenomus* sp.) on the eggs of Tea mosquito bug.

Period of culturing	No. of host eggs exposed	No. of parasitoids emerged out	No. of parasitoids failed to emerge out	% Parasitisation
Aug 91	40+	3*	14	42.5
Dec 91	88+	14**	13	30.7
Mar 92	62++	20**	N.R.	32.3

+ Eggs laid on cashew shoots

++ Eggs laid on cotton shoots

\* Emerged on 45th day

\*\* Emerged between 17th and 20th day

N.R. = Not recorded as the shoots containing host eggs had been completely decomposed because of saprophytic fungal growth

## QUALITY ANALYSIS AND POST HARVEST TECHNOLOGY

Studies on biochemical changes during storage of nuts and apples were continued. Kernel starch and sugar contents tend to decrease during storage both at low and ambient temperature. Lysine content also decreases while, protein content did not follow any specific trend. CNSL content (estimated as phenols) tend to decrease during storage. The relative concentration of three fractions of storage protein did not change although the ratio of albumin to globulin decreased initially followed by an increase. Sorbic acid and potassium metabisulphite and citric acid were not effective in extending the storage life of cashew apples.

# Biochem. I : Studies on biochemical changes during storage of cashew nuts and apples

(KV Nagaraja)

The project was initiated with an objective of studying biochemical changes during storage of nuts and apples and arriving at a suitable temperature for storage of cashew apples. Cashew nuts after storage

both at ambient and low temperature were analysed for protein, starch, sugars and lysine contents. Defatted cashew kernel flour was used for analysis. Results are presented in Table 55. At both the storage

Table 55. Changes in Kernel biochemical constituents during storage\*

Storage temperature (°C)	Variety	Storage period (days)	Sugars (g/100g)	Starch (g/100g)	Protein (g/100g)	Lysine (µg/mg protein)
30	VRI-1	0	9.64	37.72	71.65	42.41
		70	7.84	35.94	85.94	32.62
		140	6.89	26.65	84.93	33.93
		210	8.82	21.87	62.65	37.33
		280	9.97	41.17	79.08	38.88
		350	7.43	36.43	81.69	43.92
		490	6.85	29.91	90.63	34.72
	VRI-2	0	10.49	46.43	73.19	37.77
		70	7.56	38.08	69.72	37.95
		140	8.55	29.30	75.56	36.47
		210	12.34	35.42	66.20	40.33
		280	9.09	36.45	83.03	39.99
		350	9.19	32.70	74.38	43.18
		490	12.41	34.33	77.13	36.74
6	VRI-1	70	8.15	27.87	85.96	30.28
		140	8.33	27.57	81.63	32.33
		210	7.25	30.99	68.25	29.37
		280	7.38	33.84	86.24	35.61
		350	7.19	20.79	84.26	31.27
		490	8.80	30.41	86.56	30.58
		VRI-2	70	8.28	36.27	90.21
	140		9.68	24.31	74.44	38.83
	210		11.23	24.65	73.37	29.07
	280		9.43	34.57	83.93	35.12
	350		8.61	34.72	70.48	24.27
	490		8.89	35.95	81.06	31.41

\* Values are means of three individual estimations.

temperature starch and sugars tend to decrease during storage. Lysine content also tends to decrease while changes in the protein content did not follow any specific trend.

Changes in the shell CNSL content were followed during storage of nuts both at ambient and low temperature and the results are presented in Table 56. CNSL content tend to decrease during storage.

Different fractions of storage protein were sequentially extracted from defatted cashew kernel flour and estimated. Results

are presented in Table 57. During storage, relative distribution of three different fractions of storage proteins does not change. The ratio of albumin to globulin, however, shows an initial decrease followed by an increase. Electrophoresis of different fractions of storage proteins did not reveal any difference in the banding pattern during storage of nuts.

Attempts were made to extend the storage life of cashew apples both at ambient temperature and low temperature by dipping the fruits separately for 30 min in a mixture containing 0.5 per cent potassium

Table 56. Changes in CNSL\* content during storage.

Storage temperature (°C)	Variety	Storage period (days)	CNSL (mg phenol/g shell)
30	VRI-1	0	61.95
		70	57.00
		140	46.22
		210	67.70
		280	29.83
	VRI-2	0	57.39
		70	53.84
		140	54.24
		210	45.43
		280	24.69
6	VRI-1	70	51.89
		140	43.83
		210	74.23
		280	25.36
	VRI-2	70	66.72
		140	45.01
		210	51.77
		280	25.05

\* Estimated as phenols.

**Table 57.** Relative distribution of different fractions of proteins during storage of nuts.

Storage temperature (°C)	Variety	Storage period (days)	Albumin/ Globulin	Albumins (mg protein extracted/100 mg defatted flour)*	Globulins	Glutelins	
30	VRI-1	0	2.57	10.51	4.43	32.35	
		70	1.05	5.15	4.89	29.89	
		140	1.56	7.75	4.96	29.34	
		210	1.75	14.45	8.25	32.15	
		280	2.18	8.73	4.01	40.13	
		350	1.99	8.04	4.04	42.50	
	VRI-2	0	1.27	4.96	3.90	28.95	
		70	1.06	6.23	5.88	23.69	
		140	1.29	6.04	4.69	22.33	
		210	1.72	10.99	6.39	30.63	
		280	1.55	8.63	5.55	31.66	
		350	1.40	7.54	5.38	40.28	
	6	VRI-1	70	1.09	6.24	5.72	38.66
			140	1.30	4.53	3.47	24.93
210			1.87	10.06	5.39	35.57	
280			3.20	12.47	3.89	33.98	
350			1.59	4.91	3.07	45.46	
VRI-2		70	1.23	7.13	5.78	29.08	
		140	1.29	4.80	3.70	16.95	
		210	1.66	8.67	5.22	30.07	
		280	2.09	8.55	4.08	29.86	
		350	1.11	5.94	5.32	42.21	

\* Values are mean of three individual estimations

metabisulphite and 0.1 per cent citric acid and 0.5 per cent sorbic acid. PLW was recorded and the results are presented in Table 58. Although, PLW is less in fruits stored in polythene pouches with holes, the treatment (potassium metabisulphite and citric acid) failed to control microbial spoilage and extend the storage life. Cashew

apples when stored at low temperature alone exhibited greater loss of moisture although microbial spoilage was minimum. Thus, the chemicals tried potassium metabisulphite, citric acid and sorbic acid are not effective in extending the storage life of cashew apples at low temperature.

Table 58. Physiological loss in weight (PLW) of cashew apples during storage at 10°C (%)

Storage period (days)	0.5% potassium metabisulphite and 0.1% citric acid		0.5% sorbic acid
	A	B	
0	0	-	0
2	2.3	7.7	6.8
4	4.2	32.2	18.7
6	6.1	-	28.2
8	9.0*	26.0	37.4
10	-	31.7	45.8
12	-	-	53.0
14	-	45.0	-

A Stored in polythene pouches with holes.

B Stored without polythene pouches.

\* Most of the fruits were spoiled due to microbial infection.



# Gen. I(443) : Production of parental materials and breeders' stock of cashew

(KRM Swamy and B Nagaraja)

This project was started under the Revolving Fund Scheme for cashew grafts production. The objective of this project is to take up commercial multiplication of released varieties and other elite materials for distribution to government agencies/nurserymen (for establishing scion banks) and to the farmers.

## Production of Planting materials

Softwood grafts of released cashew varieties and other elite materials were commercially multiplied, from August 1991-March 1992. During this period, a total number of 45,449 softwood grafts were prepared, of which 31,162 were successful with a mean success of 68.5 per cent. Seedlings of VTII-174 were used as root stocks for grafting. The highest per cent of graft success was recorded during September (81.8%), followed by August (77.3%) and

October (65.1%). The lowest per cent of graft success was recorded during January (36.6%) and the poor success recorded during January was due to the non-availability of mature scion sticks (Table 59).

## Supply of planting materials :

During the year 1991-92, 30,215 cashew grafts of different varieties/elite materials were sold to the farmers and other agencies with the realisation of Rs.2,11,950 towards revenue.

## Maintenance of Cashew scion banks :

The cashew scion banks both at Shantigodu (22 varieties at 100 grafts/variety) and Puttur (4 varieties at 100 grafts/variety) were maintained. A total of 45,449 scion sticks were collected from these scion banks and other plots for grafting purpose.

Table 59. Cashew grafts produced during 1991-92

Month	No. of grafts made	Graft success	
		No.	%
Aug 1991	10,675	8,254	77.3
Sep 1991	10,476	8,573	81.8
Oct 1991	8,440	5,495	65.1
Nov 1991	3,775	2,277	60.3
Dec 1991	3,810	1,958	50.8
Jan 1992	2,223	815	36.6
Feb 1992	1,270	780	61.4
Mar 1992	4,750	3,010	63.3
Total	45,449	31,162	68.5

(KRM Swamy)

The objective of this project is to establish a link between research personnel of the Institute and extension officials of Development Departments and farmers by organizing training programmes on various aspects of cashew production technology.

Two training programmes on 'Vegetative Propagation of Cashew' were conducted during July and August 1991. A total of 44 personnel were trained which included 20 farmers and 24 officials (Table 60).

A two days training programme on 'Pest and Disease Management of Cashew' was organized during November 1991 and 11 officials attended (Table 60). A four days training programme on 'Cashew Pro-

duction Technology' was conducted during January 1992 and six officials belonging to development departments participated (Table 60). Besides the scheduled training programmes, two training programmes of one day duration each, namely, 'Training and Pruning in Cashew' and 'Forecasting of Yield in Cashew Plantations' were organised. Nine officials attended the training programme on 'Training and Pruning in Cashew' and 13 officials attended the programme on 'Forecasting of yield in cashew plantations'. A total of 83 persons from seven states were trained on different aspects of cashew production technology in these training programmes involving 20 farmers and 63 officials belonging to development departments (Table 61).

Table 60. Training programmes conducted during 1991-92

Course title	Date(s)	Duration (days)	No. of participants
Vegetative Propagation of Cashew	25-27 Jul 91	2	20
	and 20-23 Aug 91	3	24
Pest and Disease Management of cashew	12-13 Nov 91	2	11
Cashew Production Technology	07-10 Jan 92	4	6
Training and Pruning in Cashew	24 Sep 91	1	9
Forecast of yield in cashew plantations	25 Feb 92	1	13
<b>Total</b>			<b>83</b>

**Table 61.** Training programmes conducted and number of participants from different states during 1991-92

Course title	No. of participants							Total
	Tamil Nadu	Kannada	Kerala	Andhra Pradesh	Madhya Pradesh	Goa	Maharashtra	
<b>Vegetative Propagation of Cashew</b>								
Farmers	—	17	3	—	—	—	—	20
Officials	—	12	2	5	1	2	2	24
<b>Pest and Disease Management of Cashew</b>	1	—	—	8	1	—	1	11
<b>Cashew Production Technology</b>	—	—	—	5	1	—	—	6
<b>Training and pruning in Cashew</b>	—	9	—	—	—	—	—	9
<b>Forecasting of yield in cashew plantations</b>	—	13	—	—	—	—	—	13
<b>Total</b>	1	51	5	18	3	2	3	83

#### **Extn. IV(443) : Research cum Demonstration plots**

(KRM Swamy, N Bakthavatsalam (Upto 28-11-1991) and  
P Shivarama Bhat From 1-2-1992)

The objective of this project is to demonstrate the new technologies developed in the farmers' fields by establishing demonstration plots.

Twenty four cashew demonstration plots of 0.4 - 0.8 ha each which were established during 1988-89 in Puttur, Buntwal and Belthangady taluks of Dakshina Kannada were monitored during the year. Out of 14 cashew demonstration plots of 0.8 ha each established during 1989-90 in Belthangady taluk by Shree Kshetra Dharmastala Rural Development Project

(SKDRDP) in collaboration with NRC Cashew, 12 plots are being monitored by SKDRDP Field Supervisors and the remaining two plots were discontinued as these plots were not maintained well by farmers concerned. This programme is sponsored jointly by the Directorate of Cashewnut Development, Cochin, and NRC Cashew, Puttur, under the Central Sector Scheme. Cost of establishment and maintenance for these demonstration plots in the form of subsidy towards the purchase of cashew grafts, fertilizers and insecticides was met by the Directorate of Cashewnut Develop-

ment, Cochin. A total of Rs. 85,658 has been given to the cashew demonstration farmers as subsidy by the Directorate of Cashewnut Development, Cochin, between 1988 and 1992 (Table 62). The total amount spent by the farmers for establishing and maintaining 0.8 ha cashew plot during the

first four years ranged from Rs. 3715 to Rs.13,070 depending upon the nature of the plot (Table 63). During fourth year, the yield realised ranged from 5 kg to 210 kg/0.8 ha plot. The poor yield realised from some of the plots was due to tea mosquito infestation.

Table 62. Subsidy given to cashew demonstration farmers by the Directorate of Cashewnut Development, Cochin between 1988 and 1992

Year	Amount of subsidy (Rs.)
First	12,311
Second	20,624
Third	28,169
Fourth	24,554
Total	85,658

Table 63. Expenditure incurred by the farmers for establishing and maintaining 0.8 ha cashew demonstration plots

Year	Expenditure (Rs.)	
	Minimum	Maximum
First	1,305	6,510
Second	810	2,870
Third	1,000	2,530
Fourth	800	1,160
Total	3,715	13,070

## Summary Report of All India Coordinated Cashew Improvement Project

The All India Coordinated Cashew Improvement Project has seven centres of which four were started at the inception of AICS & CIP in 1971 (Bapatla, APAU; Anakkayam, KAU; Vengurla, KKV and Vridhachalam, TNAU), one started during Fifth Plan period (Bhubaneswar, GIAT) and two more were added during Sixth Plan (Jhargram, BCKV and Chintamani, IAS). The budget allocation for the Project for the year 1991-92 is Rs. 22.67 lakhs (Rs. 17.00 lakhs ICAR share). During 1991 - 92 the expenditure was Rs.18.46 lakhs (Rs.13.84 lakhs ICAR share). The project mandate is to increase production and productivity of Cashew through :

- \*\* Evolving high yielding varieties resistant/tolerant to diseases and pests
- \*\* Standardizing agrotechniques for the crop under different agroclimatic conditions
- \*\* Evolving effective pest and disease management practices.

**Summary of the results of current year are presented below :**

### Crop Improvement

A total of 813 cashew germplasm accessions (Bapatla -117; Bhubaneswar-74; Chintamani 72; Jhargram-III; Madakkathara -99; Vengurla-161 and Vridhachalam-179) are being maintained and evaluated in different centres. It was found that five accessions from Bapatla (T-14, 241, 232, 71 and 6/20), 1 from Bhubaneswar (T.No.40), two

from Vengurla (89/12/3 and 83/5/3) and six from Vridhachalam (ME 15/2, A 15/4, A 7/2, M 55/4, M 44/3 and A 5/3) gave a high yield of more than 10 kg/tree. During the year a total of 172 accessions showing promising characters were collected by different centres (Bhubaneswar - 10; Chitamani -20; Jhargram-3; Madakkathara -15; Vengurla - 2 and Vridhachalam -22) and added to the germplasm conservation block.

In multilocation trial 17 varieties collected from different centres (Vittal, Vridhachalam, Vengurla and Bapatla) were planted in all the centres and are being evaluated.

Two varieties viz., VRI - 3 and V - 6 were released from Vridhachalam and Vengurla respectively. VRI-3 gave an yield of 14.19 kg/tree for a period of over 14 years and mean nut weight of 7.2 g and shelling percentage of 29. In V-6 the yield was 16.5 kg/tree/year (mean of eight years) with a nut weight of 7.94 g and shelling percentage of 28.

Evaluation of  $F_1$  hybrids showed that five hybrids from Bapatla (2/3, 2/16, 3/13, 3/28 and 3/30) gave a mean yield of more than 10 kg/tree for the last seven years. Similarly the hybrids 1597, 1598, 1608 and 1610 showed mean yield of above 10 kg/tree for the last 14 years at Madakkathara. At Vengurla, among 1431  $F_1$  hybrids which are under evaluation, 16 hybrids gave a nut weight of more than 6 g.



New Vengurla variety released in 1991

#### Propagation and Root stock studies

Softwood grafting was found to be the best method for vegetative propagation. A good graft success of 63 to 86 per cent at Bapatla, 63 to 80 per cent at Bhubaneswar 65 per cent at Jhargram and 68 per cent at Vridhachalam was observed. Flush grafting was not successful at all the centres except Vengurla.

A good success in top working was noticed in Bapatla (50 to 54%), Bhubaneswar (61 to 90%) and Madakkathara (63%). At Madakkathara and Vengurla the four year old top worked plants gave a yield around 5 kg/tree.

#### Agronomy

In NPK trial, application of N (0,500, 1000g/plant),  $P_2O_5$  (0, 125, 250 g/plant) and  $K_2O$  (0,125, 250 g/plant) showed that  $N_3K_3$ ,  $N_2K_1$  and  $N_2P_2$  combinations at Bhubaneswar,  $P_3K_2$ ,  $N_3P_1K_1$  and  $N_3P_1$  at Chintamani increased the yield.

In foliar application of urea along with insecticides, increase in yield and nut production was observed in Bapatla and Vengurla (2% and 4% urea spray), Bhubaneswar (3% urea spray), Jhargram (2%, 3% and 4% urea spray) and Vridhachalam (3% and 4% urea spray).

At Bapatla, biochemical analysis of leaf samples showed that N,P,K, Ca and Mg in different leaves of a twig did not differ significantly. In third leaf, however, all these components are marginally higher.

#### Crop Protection

Among the seven insecticides (old treatment) tried at Bapatla, Bhubaneswar and Jhargram, carbaryl, monocrotophos and methyl parathion effectively controlled the tea mosquito and other minor pests. Among the modified treatments the trees which received all the three sprays of monocrotophos, endosulfan and carbaryl and two sprays of monocrotophos and endosulfan controlled the tea mosquito and other pests at Chintamani and Madakkathara respectively. At Vengurla, endosulfan and carbaryl (2 sprays) and monocrotophos, endosulfan and carbaryl (3 sprays) showed least incidence of pests. The large plot trial conducted with recommended chemicals at Vridhachalam for three years showed an increase in yield.

Application of coal tar:kerosene (1:2), BHC and Kaoline were found to be promising in the control of stem and root borer in different centres.

Bioecology of tea mosquito, leaf miner, leaf and blossom webber, leaf thrips, inflorescence thrips, fruit and nut borer (Chintamani), stem and root borer, shoot tip and inflorescence caterpillar, leaf folder, leaf thrips (Vridhachalam) were studied. A

survey for recording pest intensity, season of occurrence and natural enemies have been made by all the centres.

Screening of germplasm for identifying/locating resistant/tolerant types have been carried out. A total of 47 accessions (Chintamani-5; Jhargram-9; Madakkathara-13; Vridhachalam-20) were less susceptible to tea mosquito and other minor pests.

## PARTICIPATION IN SYMPOSIA/CONFERENCES

- |    |  |  |                                 |
|----|--|--|---------------------------------|
| 1. | Staff Research Council Meeting of CPCRI and Committee meeting of Cashew Variety Release  | EVVB Rao   | 18-25 Apr 1991                  |
| 2. | Staff Research Council Meeting of ICAR Research Complex for Goa, Goa   | EVVB Rao   | 06-07 May 1991                  |
| 3. | Summer Institute on host plant resistance to insect pests and its application in insect pest management, TNAU, Coimbatore                  | D Sundararaju  | 06-25 Jun 1991                  |
| 4. | Group Discussion of Research Workers on Spices, Trivandrum   | EVVB Rao   | 26-28 Jul 1991                  |
| 5. | Entomologists Group Meeting of Horticulture Division of ICAR, IISR, Lucknow  | EVVB Rao<br>D Sundararaju<br>PS Bhat   | 12-13 Aug 1991                  |
| 6. | National Group Discussion of Cashew Research Workers, CPCRI, Kasaragod   | EVVB Rao<br>PM Kumaran<br>N Yadukumar<br>D Sundararaju<br>M Gangadhara Nayak<br>KV Nagaraja<br>K Palanisamy<br>KRM Swamy<br>Thimmappaiah<br>N Bakthavatsalam | 30-31 Aug 1991 &<br>01 Sep 1991 |
| 7. | Seminar on Cashew Cultivation, Thirthahally (organized by Rotary Club of Thirthahally and Rotary Gramina Dala, Bharathipur, Shimoga Dist.) | KRM Swamy<br>N Yadukumar   | 26 Sep 1991                     |

8.	Group Discussion of Palms Research Workers, CPCRI, Kasaragod	EVVB Rao	25-29 Sep 1991
9.	VII Business Meeting of Officers of Horticulture/Plantation Discipline, arranged by NABARD, Bombay, at Bhubaneswar	EVVB Rao	03-04 Oct 1991
10.	Workshop on Integrated Development of Spices and Horticultural Crops. RARS, Ambalavayal, Wynad	EVVB Rao	26-27 Oct 1991
11.	International Symposium on Coconut Research and Development (ISOCRAD-II) CPCRI, Kasaragod	EVVB Rao PM Kumaran	26-29 Nov 1991
12.	Workshop on Biotechnological Approaches in Biological control. Entomology Research Institute, Loyola College, Madras	D Sundararaju	20-27 Jan 1992
13.	Organizing Committee Meeting of National Workshop on Integrated Development of Cashew	EVVB Rao	27 Jan 1992
14.	National Workshop on Integrated Development of Cashew, Kannur, Kerala	EVVB Rao PM Kumaran N Yadukumar KRM Swamy KV Nagaraja D Sundararaju	01-02 Feb 1992

### Research Publications

1. KRM Swamy and OP Dutta. 1991. Coheritable variation in muskmelon (*Cucumis melo* L.). *Indian J. Agri. Res.* **25**: 149-153
2. KRM Swamy and E Mohan 1991. Screening of cashew varieties/types for root stock at nursery stage. *The Cashew* **5** (2) : 3-5
3. PS Bhat. 1991. Chemical control of sweet potato weevil in Orissa. *J. Root Crops* **17** (2) : 147-149.

## Papers presented in Symposia/Workshop

1. EVV Bhaskara Rao, RV Pillai and MJ Ratnambal. 1991. Current status of coconut genetic resources research in India. ISOCRAD II. CPCRI Kasaragod, 26-29 November, 1991.
2. EVV Bhaskara Rao. 1992. Technologies available for increasing production and productivity in cashew. National Workshop on Cashew. Kannur, 1-2 February 1992.
3. KRM Swamy. 1992. Clonal propagation of elite planting materials of cashew softwood grafting - A novel technique. National Workshop on Cashew, Kannur. 1-2 February, 1992.
4. PM Kumaran. 1992. Elite strains of cashew of national importance with specific relevance to Kerala. National Workshop on Cashew, Kannur. 1-2 February 1992.
5. NYadukumar. 1992. Management of clonal cashew gardens Adoption of comprehensive production technology - A way to increase production. National Workshop on Cashew. Kannur, 1-2 February 1992.
6. D Sundararaju. 1992. Pest problems in cashew and control measures thereof. National Workshop on Cashew. Kannur, 1-2 February 1992.
7. KV Nagaraja. 1992. Harvesting and post-harvest care of cashew nuts and apples. National Workshop on Cashew. Kannur. 1-2 February 1992.
8. RC Ray, PS Bhat and PP Kumar. 1991. Post-harvest utilisation of sweet potato in Orissa. International Workshop on Post-harvest handling and utilisation of sweet potato. CTCRI, Trivandrum 9-13 September 1991.

## Technical Bulletins

1. NRCC Research Highlights 1991-92: March 1992. 16 pp. (Compiled and Edited by EVV Bhaskara Rao and KV Nagaraja)
2. NRCC Annual Report 1990-91. September 1991. 112 pp. (Compiled and Edited by EVV Bhaskara Rao, KV Nagaraja and Thimmappaiah)
3. All India Coordinated Cashew Improvement Project. Annual Report 1990-91. July 1991. pp. 127 (Compiled and Edited by EVV Bhaskara Rao and K Palanisamy)
4. All India Coordinated Cashew Improvement Project. Summary Report (1989-91) for presentation at National Group Discussion of Cashew Research Workers 30-31 August and 1 September 1991. CPCRI Kasaragod. pp.156 (Compiled and Edited by EVV Bhaskara Rao and K Palanisamy)
5. Proceedings of National Group Discussion of Cashew Research Workers 30-31 August and 1 September 1991. September 1991. pp.84 (Compiled and Edited by EVV Bhaskara Rao and K Palanisamy)
6. NRC Cashew 1986-91 Programmes and Achievements. November 1991. pp.36 (Compiled and Edited by EVV Bhaskara Rao and KV Nagaraja)
7. All India Coordinated Cashew Improvement Project. One Decade Research

Achievements 1981-91. August 1991 pp. 14 (Compiled and Edited by EVV Bhaskara Rao and K Palanisamy)

8. NRCC - Softwood Grafting - Technique for Commercial multiplication of Cashew Varieties. August 1991. pp.10 (Compiled and Edited by EVV Bhaskara Rao, and KV Nagaraja (Text prepared by KRM Swamy)
9. NRCC - Vegetative propagation of cashew. 1992. pp.20 (Edited by EVV Bhaskara Rao, Text prepared by KRM Swamy and E Mohan)
10. Current status of Coconut Research and Development in the world. 1991. CPCRI Kasaragod. 36 pp. (Compiled and Edited by MK Nair, EVV Bhaskara Rao, H Hameed Khan and P Gopalasundaram)

## Important Visitors

- 18 May 1991 Sri K Narasimha Murthy, Retired Joint Director, CPCRI Regional Station, Vittal
- 29 Aug 1991 Dr. KL Chadha, Deputy Director General (Hort.) ICAR, Krishi Bhavan, New Delhi  
Dr P Bethnam, Assistant Director General (FC) ICAR, Krishi Bhavan, New Delhi
- 26 Sep 1991 Dr SB Kadrekar, Vice Chancellor, Konkan Krishi Vidyapeeth, Dapoli, Maharashtra  
Sri TA Sriram, Sr. Technical Officer (PC), ICAR, Krishi Bhavan, New Delhi
- 28 Sep 1991 Sri Paramjit Singh, Assistant Commissioner (Hort.), Department of Agriculture & Cooperation, New Delhi
- 23 Oct 1991 Dr IS Dua, Professor, Department of Botany, Punjab University, Chandigarh
- 25 Oct 1991 Dr MRN Rao, Director of Agriculture, Port Blair, Andamans
- 25 Nov. 1991 Dr. Balram Jakhar, Honourable Union Minister of Agriculture & Cooperation, Government of India  
Sri Mullappalli Ramachandran, Honourable Union Minister of State for Agriculture, Government of India
- 06 Nov 1991 Dr GL Kaul, Assistant Director General (Hort.) ICAR, Krishi Bhavan, New Delhi  
Dr Abhaya M Dandekar, Assoc. Professor, Dept. of Pomology, University of California, Davis, California, USA.  
Richard E Litz, Professor, Tropical Research and Education Centre, University of Florida, Homestead, Florida, USA.
- 28 Dec 1991 Ms. Santha Sheela Nair, Jt. Secretary and Horticulture Commissioner, Government of India, Ministry of Agriculture, New Delhi  
Sri E. Velappan, Director, Directorate of Cocoa, Arecanut and Spices Development, Kozhikode
- 31 Jan 1992 Dr Prakash Mahindre, Director of Horticulture, Maharashtra State, Pune

## Weather Data for the year 1991-92

Month	Temperature (°C)		Humidity (%)		No. of rainy days	Total rainfall (mm)	Sunshine (hr/day)	Evaporation (mm/day)	Wind velocity (km/hr)
	Max.	Min.	Fore noon	After noon					
Apr 1991	35.6	24.1	91.3	57.5	5	39.3	8.30	6.29	4.60
May 1991	35.4	24.3	89.0	52.0	8	125.2	8.10	6.00	4.50
Jun 1991	29.6	23.7	95.0	83.0	25	940.4	2.20	3.49	4.70
Jul 1991	28.2	22.5	95.0	80.0	29	1328.0	2.03	3.69	5.36
Aug 1991	28.3	22.5	96.0	80.0	25	906.7	2.46	3.17	3.36
Sep 1991	31.3	22.6	94.0	65.0	4	43.5	6.20	3.61	3.15
Oct 1991	31.8	21.2	97.0	62.0	10	121.6	6.16	3.37	2.85
Nov 1991	32.4	21.1	90.0	50.0	3	74.3	7.40	3.70	2.80
Dec 1991	33.7	19.2	86.0	41.0	—	0.8	9.57	4.41	4.28
Jan 1992	33.7	15.1	89.0	25.0	—	—	9.70	5.10	4.04
Feb 1992	33.5	17.6	92.0	42.0	—	—	9.30	5.15	3.32
Mar 1992	36.4	20.8	91.0	40.0	—	—	9.30	5.90	4.30