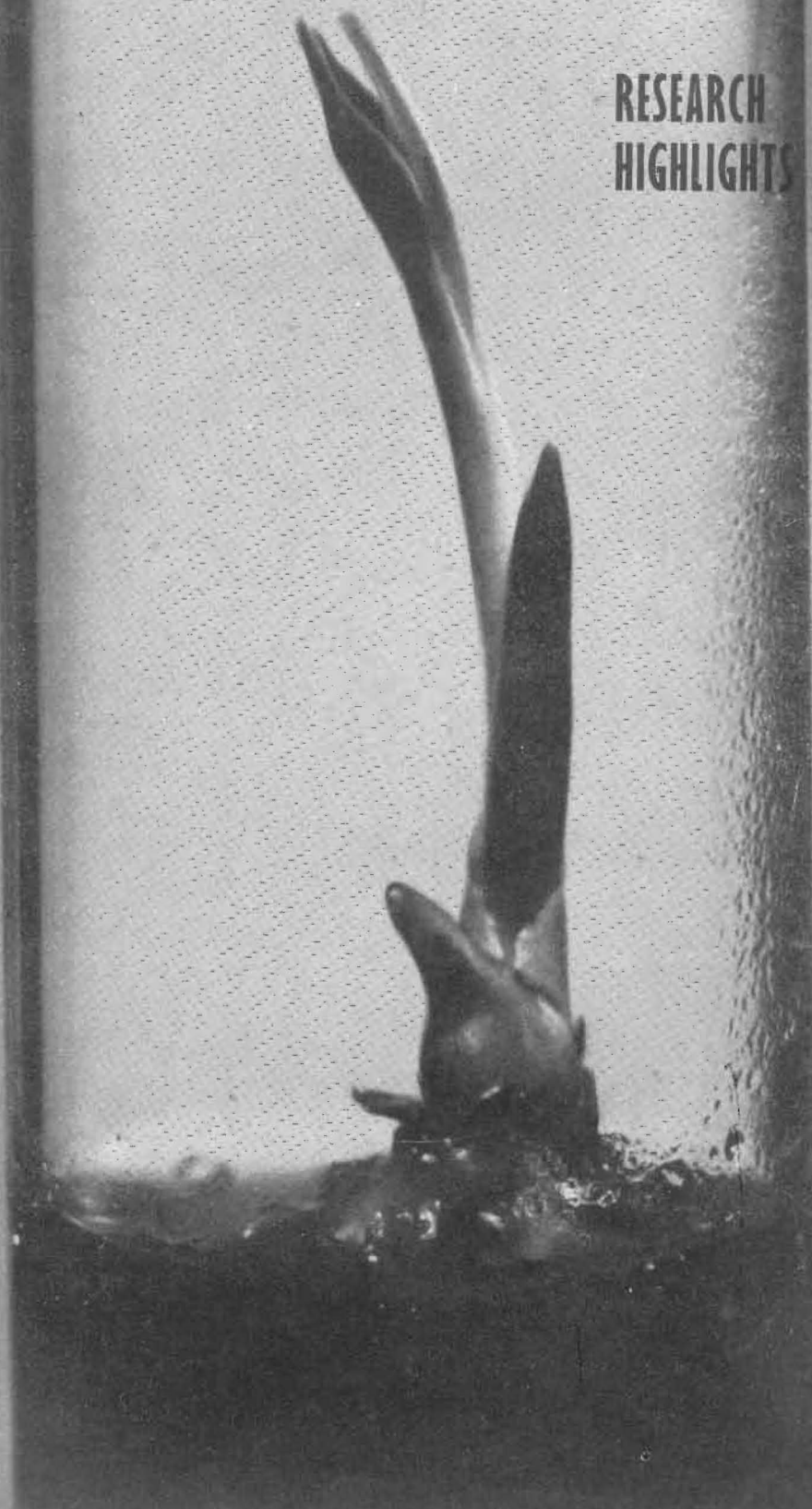




Central Plantation Crops Research Institute
Kasaragod-670 124, Kerala, India

**RESEARCH
HIGHLIGHTS 1984**



Front cover: Coconut plantlet from leaf tissue culture in a test tube



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Central Plantation Crops Research Institute
Kasaragod 670 124, Kerala, India

Published by :

K. V. Ahamed Bavappa
Director, Central Plantation Crops Research Institute
Kasaragod 670 124, Kerala, India

Compiled and edited by :

M. K. Nair

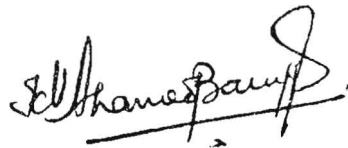
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INTRODUCTION

The Central Plantation Crops Research Institute conducts and co-ordinates research on coconut, arecanut, oil palm, cashewnut, cocoa and spices. Among the spices, pepper, cardamom, ginger, turmeric, clove, nutmeg and cinnamon are the more important crops being researched upon. The activities of the Institute are spread over 16 centres. During the 12th Annual Research Council Meeting of CPCRI held in January-February '84, the ongoing 91 projects were regrouped into 28 mega projects having broad objectives so as to obtain higher inter-disciplinary interaction in work. In addition to the thrust areas already identified for the year 1983, concentrated efforts on (1) collection, conservation and exploitation of genetic resources (2) studies on water management and stress physiology (3) perennial crop based mixed cropping system to enhance small holders' income from unit area of land (4) establishment of country-wide network of seed gardens to ensure adequate supply of planting materials (5) tissue and anther culture research and (6) developing effective systems for transfer of available technology were decided to be undertaken. A number of outreach programmes were also organised. In general the rearranged and concentrated efforts on thrust areas yielded very useful results. The success in tissue culturing coconut for the first time, transmission of MLO, the root (wilt) pathogen, from diseased coconut palms to periwinkle, a precise estimation of the damage due to root(wilt) disease etc. were some of the major outcome of the efforts made during the year.

The highlights of R & D efforts of CPCRI for the year 1984 are covered in this publication.



(K. V. AHAMED BAVAPPA)
Director

Kasaragod
March 6, 1985

Central Plantation Crops Research Institute

Root (wilt) disease of coconut

The lace bug *Stephanitis typica* which is present in the contiguously root (wilt) disease prevalent areas, feeds through the stomata and the length of the stylet is indicative of its capability to reach the inner tissue of the palm leaf. A direct linear correlation between abundance of lace bugs on coconut palms and fresh incidence of root (wilt) disease has been established. Electron microscopic examination of ultra-thin sections of lace bugs with 18, 19 and 20 days of acquisition/incubation periods revealed the presence of mycoplasma-like organisms (MLOs) in the salivary glands and brain tissues. These evidences indicate that the lace bug is the most probable vector in the transmission of the root (wilt) disease.

When, dodder (*Cassytha filiformis*) established on a four-year old diseased palm was bridged to periwinkle plants maintained under insect proof conditions, the test plant showed symptoms typical of MLO infection. Mycoplasma-like organisms were detected in the sieve tubes of petioles of periwinkle and dodder.

Retention of oxytetracycline in the kernel of palms treated with the chemical was observed upto 37 days after injection. However the presence of residues of the chemical in the kernel was detected only in palms which received 6 and 9 g active ingredient of the chemical.

The sero-diagnostic test to detect the disease before symptom expression was refined and it compared well with the physiological test based on stomatal resistance. The flaccidity symptom of the root (wilt) diseased palms could be attributed to changes in water potential components, particularly leaf water potential.

Adoption of integrated management practices in disease affected gardens could increase the average yield of coconut by 10.3 nuts per palm over the control under rainfed conditions during the third year of the treatment and 8.8 nuts per palm under irrigated conditions during the second year of the treatment. Incorporation of leguminous green manures (*Calapogonium* and *Pueraria*) in coconut basins in root (wilt) affected tracts increased the total nitrogen, available phosphorus and potassium contents of the basin-soils.

A comprehensive survey in eight districts (Trichur to Trivandrum) of Kerala undertaken by CPCRI in collaboration with the Directorate of Agriculture, Kerala Agricultural University, Coconut Development Board, Special Agricultural Development Unit, Directorate of Economics and Statistics, Central Plant Protection Station and Centre for Development Studies, indicated that out of 32.36 million non-bearing palms, 4.3 million are in the early stages of the disease, and 1.05 million are in the advanced stages. A total of 24.2 million bearing palms, out of 59.2 million, was affected

by the disease resulting in an estimated loss of 903 million nuts worth rupees 3000 million.

Yellow leaf disease of arecanut

Electron microscopic examination of more number of samples confirmed constant association of mycoplasma like organisms in the phloem tissues of yellow leaf disease affected palms, while MLOs were conspicuously absent in the tissues of healthy palms. Inventory of insects in yellow leaf disease affected gardens revealed the presence of *Carvalhoia arecae* (spindle bug) *Proutista moesta* (plant hopper) and *Oliarus* sp. which are the likely vectors in the transmission of the pathogen.

Quick wilt and slow wilt diseases of black pepper

Screening tests showed that a total of 134 seedlings raised from open pollinated and irradiated seeds did not take up infection on artificial inoculation with *Phytophthora*, indicating resistance to the pathogen. Four hybrids also showed tolerant reaction on stem inoculation. The quick wilt pathogen survived in the soil for over 16 months. A three year survey in Calicut district showed that the cumulative loss of vines due to quick wilt was 10 per cent during the period.

Ten black pepper *Phytophthora* isolates from different regions of Kerala and Karnataka were examined at

University of California, Riverside. They were identified as '*P. palmivora*' MF₄. Disease potential index (DPI) of soils monitored in pepper gardens showed a clear positive correlation to the disease incidence.

One cultivar collected from Idukki showed tolerant reaction to root knot nematode. Soil and leaf samples from slow wilt affected gardens had lower levels of K while N and P levels were lower in diseased leaves only.

Radopholus similis was found in 80% and *Meloidogyne* sp. and *Trophotylenchulus* sp. were found in 85% of the gardens surveyed in Idukki district. *R. similis* was found to be highly pathogenic and caused significant reduction in growth of pepper vines. *Trophotylenchulus* sp. has been now correctly identified as *T. piperis* sp. nov.

Rhizome rot of ginger and turmeric

Simultaneous application of neem cake, metacid and Bordeaux mixture at the time of planting, and spraying metacid and drenching Bordeaux mixture three months after planting resulted in lower disease incidence at Calicut. The recovery of seed ginger was maximum in rhizomes treated with 0.3% Dithane M-45 and stored in pits lined with sand under Kasaragod conditions. *Fusarium* sp., *Pythium* sp., *Cunninghamella* sp. were the predominant fungi found during storage at both Calicut and Kasaragod.

Thanjavur wilt, ganoderma and stem bleeding complex disease of coconut

Isolation studies on stem bleeding affected coconut palms yielded *Schizophyllum commune* in addition to *Phomopsis cocoina* at Kayangulam and *Thielaviopsis* sp. at Appangala and Goa. Plant parasitic nematodes were absent both in the soil and tissue samples collected from healthy and stem bleeding affected palms.

Destructive sampling of *Ganoderma* wilt affected palms showed a marked discolouration of tissues at the base.

Tapping of healthy and Thanjavur wilt affected palms revealed that the diseased palms produced lesser quantity of toddy with reduced sugar content.

Tatipaka disease of coconut

Electron microscopic studies of the root, leaf and apical meristem tissues from four diseased and one healthy palms revealed the presence of MLOs in the diseased palms. The MLOs occur in greater concentration in tender leaves than in inflorescence rachis.

Katte disease of cardamom

Among the eight methods tried for purification of katte virus, butanol clarification method gave satisfactory concentration of virus particles. Flexuous rod shaped particles isolated from diseased clumps resembled potato virus. Fresh disease outbreak was noticed within 30 m radius from the source of inoculum, with occasional outbreaks beyond 100 m.

Perennial crop based farming systems

Plantation crops which are economically important in a number of southern and north eastern states of India form the major crop components in garden land farming. The research on perennial based farming systems aims at maximising production per unit area of garden land through biomass generation keeping in view a high income potential as the ultimate objective.

Arising out of the investigations made so far, cropping systems such as coconut and cocoa; coconut, cocoa and pepper; coconut, grass and animal system; arecanut and cocoa; arecanut, pepper and cocoa are some of the more important systems which have been taken up by a large proportion of farmers in different states. Crop models involving different crops were suggested for Andamans, West Bengal and Tamil Nadu for large scale adaptation. The economic viability of these crop combinations has been exceedingly good. In addition to generating high income, such cropping models also give fairly spread over returns and provide the farmer insulation to economic upheavals due to price fluctuations of commodities.

Investigation on root exudates from areca palm grown as a monocrop, and mixed with banana and areca in high density multispecies cropping (HDMSC) system indicated that the cropping system does not influence the exudation of sugar. Exudation of amino acids was significantly reduced

when areca was grown as a mixed crop and under HDMSC system. The amino acids exuded by areca and banana roots from different cropping systems are lysine, asparagine, serine, glutamine, alanine, tryptophan, and valine.

Water management and stress physiology

The interaction of quantity of irrigation water and frequency of irrigation had significant positive influence on coconut yield in sandy-loam soil. Palms irrigated with 20 mm water/irrigation at IW/CPE ratio of 1.0 gave the highest mean yield of 130 nuts/palm/year, followed by those irrigated with same quantity of water at the 0.75 ratio (123 nuts).

The CDO × WCT hybrid palms in shallow laterite soil receiving irrigation with 45 litres of water once in four days with mulching had highest nut yield.

A close relationship between the low diffusive resistance, and high transpiration rate resulting in low leaf water potential and subsequent appearance of flaccidity symptoms has been observed. This could be confirmed in the field studies. When the root (wilt) diseased palms were irrigated with 250–500 l water per palm during the summer months there was marked reduction in the flaccidity of leaves.

Production physiology

A study on the leaf area, dry matter production, chlorophyll content and nitrate reductase activity in one-year old seedlings belonging to five hybrid combinations viz.,

MDY × WCT, MDY × Kenya Tall, MDY × Zanzibar Tall, MDO × WCT and CDO × WCT revealed that MDY × WCT was superior to all other combinations including CDO × WCT. It was also found that the uptake of nitrate was maximum by 30th day after N application.

The NR activity in adult coconut palms is significantly and positively correlated with yield of nuts ($r=0.67$). The activity of this enzyme attains a maximum at relatively low levels of NO_3 in the medium in high yielders as compared to the low yielding palms.

Nutritional requirement and crop management

In the permanent observation trial, palms under cultivation and fertilizers with or without organic manure application produced the highest yield of 58 nuts/palm/year followed by 45 nuts/palm/year in palms receiving minimum tillage around the basin with fertilizer application and most of the palms under totally neglected conditions did not even flower.

Work on fertilizer and irrigation responses of high yielding coconut genotypes revealed that CDO × WCT hybrid when irrigated gave the highest annual yield of 98 nuts/palm at 500 g N + 500 g P + 1000 g K/palm/year as compared to 45 nuts under no irrigation. The palms receiving irrigation of 20 mm at IW/CPE ratio of 1.0 had the highest yield of 130 nuts as compared to 69 nuts in the control.

Application of fertilizer in cashew with N at 500g/tree/year doubled the average yield.

Soil fertility, nutrient dynamics and crop production

Simulation studies (3200 mm rainfall) on leaching of applied nutrients indicated a loss of 65-70 per cent nitrogen and 8-13 per cent of potash beyond the feeding zone (1 m) in red sandy loam soil and a similar trend was noticed in laterite soil. Secondary loss of considerable quantities of Cu (0.2 - 0.3 ppm), Zn (1.2 - 2.9 ppm) and Mn (0.6 - 1.4 ppm) was also observed in the leachate from NPK fertilized red sandy loam soil.

Nutrient addition through filtering action in the coconut interspace cropped with multi-species was found to be 6.2, 0.073 and 0.30 kg/ha of K, $\text{NH}_4\text{-N}$ and P respectively.

A site specific fertilizer recommendation for three coconut genotypes based on soil test values using Mitschelich-Bray model has been developed.

Better tapping and conversion efficiency of soil and applied form of nutrients by $\text{CDO} \times \text{WCT}$ over WCT has been established.

Need for inclusion of Mg in the normal fertilizer application of hybrids and high yielding WCT was found essential.

The stabilized infiltration rate of red sandy loam and sandy soil was found to be 14.9-65.8 and 300.5 cm/ha

respectively which signified a rapid intake of water in both the soils.

EDTA at 0.1 M and HNO_3 at 1.0 N concentrations were found to be good extractants for studying pollution of heavy metals in soils in industrial areas. Soils and coconut palms around the industrial areas like Titanium Factory, Chavra Oil Refinery, Traco Cables and FACT in Cochin and Zuari Chemicals, Goa were found to contain toxic elements in high quantities.

Collection, conservation, evaluation and documentation of genetic resources

Ten thousand seed coconuts of the Malayan Dwarf Yellow were introduced from Malaysia under the World Bank aided Kerala Agricultural Development Project and raised in a post-entry quarantine nursery at the Seed Garden Complex, Nilambur. It is the first time such a large number of parental stock of coconut germplasm has been introduced for hybrid seed production.

Twenty cultivars of arecanut introduced from Andamans were planted for field evaluation. Collection from Mettupalayam has been added to the arecanut germplasm assemblage.

Germplasm survey carried out for cashew in Goa and in four districts of Kerala helped to identify types with specific characters and 40 collections from Goa, 22 from Kerala and 12 accessions from Cashew Research Station, Ullal were collected during the year.

Eighty eight accessions of *Piper nigrum* and related species were added to the germplasm bank during the year. During the germplasm survey of cardamom in Wynad areas of Kerala, individual clumps reported to be yielding over 50 kg of green capsules/clump/year were located and clonal materials collected from them.

Evolving high yielding varieties by selection and hybridization

Studies on the high yielding West Coast Tall progenies planted at Goa indicated that families with highest female flower production gave highest yield eventhough setting was lower than in families with lower female flower production. In T × D hybrid combinations using Laccadive Ordinary as the female parent, the average yield was 85 nuts/palm/year, whereas with Laccadive Micro as the female parent, the hybrid gave 99 nuts/palm/year. With Gangabondam as the pollen parent, the yield was 94 nuts/palm/year as compared to 81 nuts with CDO as male parent.

Tissue, anther and cell culture

Coconut clonal plantlets were produced from tissue culture of tender leaf segments through somatic embryogenesis without an initial callus phase. As many as 48 embryoids could be induced in three weeks on a single leaf explant measuring 5 mm. After a maturation period, these embryoids could be separated and induced to sprout a green shoot by aseptically excising away the root and a portion of

haustorium. These shoots were then rooted by adjusting the nutrient and hormone levels and one well developed plantlet has now been transplanted to a mixture of vermiculite and quartz sand.

In cardamom, besides the induction of multiple shoots from vegetative buds, (as many as 8 from a single bud), immature floral buds have been converted to bulbil shoots on MS medium supplemented with NAA (0.5 mg/l), Kinetin (0.5 mg/l), BAP (1.0 mg/l), Ca Pantothenate (0.5 mg/l), Folic acid (0.1 mg/l) and coconut water (10% v/v). On separation and transfer to media containing higher auxin (2 mg/l NAA) and lower cytokinin (0.05 mg/l) levels, under dark incubation, these shoots could be rooted to give clonal plants.

Integrated pest management

(a) Biological control

Establishment of *Baculovirus oryctes* virus disease in the natural population of *Oryctes rhinoceros* brought down the pest incidence on coconut palms at Minicoy. The leaf damage has come down to 20.37%, spathe damage to 2.26% and fresh incidence on spindles to 5.12% from 56.6%, 31.1% and 39.2% respectively of the pre-release condition.

Laboratory studies on the effect of virus infection showed total reduction in fecundity of beetles and approximately 40% reduction in their longevity.

Optimum doses for release of indigenous parasites of *Opisina arenosella* were worked out to 19.5% for bethylid, 35.8% for elasmid and for chalcidid 31.2% of target stages of the pest.

Techniques were developed for rearing the carabid predator *Calleida splendidula* and the ichneumonid *Goryphus nursei* in the laboratory.

Seven species of predators and three species of parasites were recorded as new additions to the natural enemy complex of the coconut caterpillar, *Opisina arenosella*.

(b) Attractants

For trapping the floating population of red palm weevil, tender coconut stems smeared with toddy and yeast or smashed sugarcane and yeast are used. As a substitute, tender coconut petioles cut into pieces can be used.

(c) Chemical control

Field control trials against pepper pollu beetle, *Longitarsus nigripennis* with three insecticides at two locations in Kottayam and Calicut districts and with seven insecticides at Calicut revealed that endosulfan 0.05% and quinalphos 0.05% were effective in controlling the pest damage on berries, when sprayed twice a year during July and October.

A sequential sampling chart prepared on the incidence of ginger shoot borer enables to judge the seriousness of pest incidence and to take a decision on the correct stage at which the

chemical control measures are to be undertaken.

Pest and disease management

(a) Pests

Early stage of red palm weevil infestation could be detected by an electronic redpalm weevil detector—the prototype of which was developed in collaboration with the Electronics Division of the College of Engineering, Trivandrum.

Placement of 2g phorate 10% granules in perforated polythene bags in the innermost leaf axils of areca palms is an effective management practice for maintenance of areca gardens free from infestation by the spindle bug, *Carvalhoia arecae*. With the production of new leaves, the polybags containing insecticide are to be shifted and kept in the new innermost leaf axils.

(b) Nematodes

Tall × Gangabondam, Chowghat Dwarf Orange × West Coast Tall, Malayan Dwarf Yellow × Jawa Giant, Klapawangi and Kenthali hybrids/cultivars in coconut were found resistant to *Radopholus similis*. Pathogenicity of *R. similis* on arecanut seedling was established.

(c) Diseases

A new virus disease called 'cardamom necrosis virus' was noticed in the Nilgiris, causing quick decline of the affected clumps. Within one year of infection, the clump becomes unproductive. The disease incidence varied from 0.1% to 5.0% in different plantations.

(c) Mycorrhizae in crop mixed coconut

The rate of increase in leaf area development and dry matter accumulation of mycorrhiza-inoculated seedlings of pepper was significantly higher than the control. Nitrate reductase activity also showed a similar trend. Mycorrhizal infection was not adversely affected by the application of recommended dosage of phosphorus. Fortification of seedlings with mycorrhizal soil containing *G. fasciculatum* helped to enhance root infection upto 90% after 5 months as against 55% in the control plants. Mycorrhiza inoculated plants registered a decrease in root-shoot ratio.

Vertebrate pest management

Two more rodent species (*Rattus norvegicus* Berkenhout and *R. blanfordi* Thomas) were recorded from the coconut-cocoa mixed habitat in Kasaragod. Two successive poison baitings with warfarin-wax blocks in coconut plantations reduced the rodent population by 95% and damage by 93%.

Quality and pesticide residue analysis

Cashew nuts and apples of 16 high yielding varieties were analysed for their free amino acids, sugars and cashewnut-shell liquid (CNSL) contents.

	% leaf oil	% bark oleoresin	% bark oil
Indian cinnamon	1.60-2.73	11.89-19.14	1.67-2.88
Sri Lankan cinnamon	2.35-3.41	6.03-12.49	0.95-3.85

Harvest and post-harvest technology

An unskilled person can dehusk 120 coconuts per hour using an

The sugar content in apples varied from 5.5 to 7.9% and in nuts from 8.8 to 19.2%. Free amino acid content in apples varied from 7 mg/100 g to 15.4 mg/100 g. In nuts the variation in free amino acid content was between 34.3 mg/100 g to 51.7 mg/100 g.

Detectable quantities of lysine, asparagine, glycine, glutamine, alanine and tryptophan were found in cashew nuts. Compositional pattern of sugar in apples and nuts was more or less similar. The presence of maltose, lactose, sucrose, glucose, fructose, cellobiose, raffinose was observed in cashew apples and nuts.

Cinnamon

One hundred and eighty-nine Indian and 102 Sri Lankan cinnamon accessions were evaluated for leaf oil, bark oleoresins and bark oils. The percentages of bark oil and bark oleoresins were higher in indigenous accessions than in Sri Lankan accessions and percentage of leaf oil was more or less similar in these two groups.

Based on the quality evaluation, six Indian and five Sri Lankan cinnamon accessions were selected for clonal multiplication and bark yield evaluation. The quality ranges of the selected accessions are :

improved pedal-operated dehusker developed by the Institute. An average force of 77 kg is required for operating the foot pedal

and a maximum force of 29 kg for operating the hand lever. About 23 seconds are required to dehusk one coconut in five unit motions using this device.

An electronic moisture meter was designed and calibrated to determine the moisture content of copra directly. The device has an accuracy of 95% for reading the moisture content in the range of 4% to 8% in dried copra.

Refinement of experimentation techniques in plantation crops

For estimating yield of pepper gardens with precision, two indices of yield potential were developed based on a visual yield score for the plant and the standardised value for yield / no. of spikes at one metre portion of the vine at breast height. The ratio method of estimation, using one of these indices as the ancillary variable was found to be nearly four times more efficient than simple average estimation.

Under Kasaragod conditions, November-December was found to be the best period for predicting the annual yield of coconuts, based on a count of the tender nuts in the crown. The regression model suggested is $y = -0.527 + 0.914x$ where y is the estimated yield and x the number of tender nuts in the crown. Under Kayangulam conditions, the model is $y = -3.0804 + 0.888x$, for the period January-March.

A plot size of 10-12 trees was found to be the optimum, for field experiments with cashew.

Based on the data for D×T palms in the early stages of flowering at Aralam and fertilizer trial at Kayangulam, the optimum plot size for D×T hybrids was determined as 8 palms arranged in two rows of four each.

A multiple regression model using nine variables [wind velocity during the first 24 weeks of the year considered in groups of four weeks, and humidity (forenoon), rainfall and number of rainy days during 13-16 weeks] was found to explain about 80% of the variation in the yield of coconuts during the succeeding year.

Estimation of crop losses

A comprehensive sample survey to estimate crop losses due to root (wilt) disease of coconut was conducted during August 1984, covering eight disease affected districts of Kerala, viz., Trichur, Ernakulam, Idukki, Kottayam, Alleppey, Quilon, Pathanamthitta and Trivandrum, jointly by CPCRI; Department of Agriculture, Kerala; Coconut Development Board, Cochin; Directorate of Economics and Statistics, Kerala; Centre for Development Studies, Trivandrum; SADU, Kerala; Kerala Agricultural University and Central Plant Protection Station, Cochin. The data gathered from the survey are summarised in Table I.

Two year's study conducted at Kayangulam revealed a significant negative correlation between disease index and the yield of coconut.

A survey conducted in Calicut district for three years indicated that the

TABLE I. Estimated crop loss due to root (wilt) disease in eight districts of Kerala

	1976 Survey	1984 Survey
Total number of palms-bearing ('000)	60837	59188
" non bearing ('000)	NA	32358
Number of diseased palms-bearing ('000)	18535	24209
" non bearing ('000)	NA	5422
Percentage of disease incidence-bearing palms	30.49	40.70
" non bearing	NA	16.76
Annual loss of nuts (million)	340	901
Monetary loss (in million rupees)		
due to loss of nuts etc.	340	2700
due to loss of copra, leaf etc.	NA	300

annual loss of pepper vines due to quick wilt disease is 1.68 lakhs and the consequent yield loss is about 114 tonnes.

Cost benefit analysis of crop production and farming systems

The Annuity Value (AV), Net Present Worth (NPW), Benefit-Cost Ratio (BCR) and Internal Rate of Return (IRR) were estimated for different crops and presented in Table II. The estimated costs and returns were discounted with 14% D. F.

The operation-wise labour requirements for various crops were assessed for different ages of plantations beginning from the year of establishment of respective crops. The estimated labour requirements in the first year of their planting and in their adult stages have been shown in Table III.

Agriculture, animal sciences and fishery research at ICAR Research Complex for Goa (CPCRI)

I. Crops

Tuber crops: Sweet potato varieties Cross-4 and Kanhangad Local were

TABLE II. Cost-benefit analysis on plantation crops (Rs/ha)

Crop	Economic life (yrs)	AV	NPW	BCR	IRR
		(at 14% DF)			
Coconut (rainfed)	60	3100	22000	1.59	19
Coconut (irrigated)	60	5400	33700	1.71	21
Arecanut (rainfed)	40	4600	32700	1.45	21
Arecanut (irrigated)	40	7900	56300	1.51	22
Cashewnut	25	650	4900	1.29	18
Cardamom	12	2500	13700	1.42	25
Pepper	15	2200	13400	1.28	25

TABLE III. Estimated labour requirements in plantation crops (man days/ha)

Operation particulars	Coconut		Arecanut		Cashewnut		Pepper		Cardamom	
	1st yr.	Adult stage (rainfed)	1st yr.	Adult stage (rainfed)	1st yr.	Adult stage	1st yr.	Adult stage	1st yr.	Adult stage
Fencing and repairs/watch and ward	70	8	70	10	8	25	50	8	80	8
Land cleaning, levelling and peg marking	55	-	150	-	70	-	30	-	56	5
Taking pits and planting	43	-	120	-	21	-	50	-	77	18
Shading, mulching, digging and weeding	25	36	105	70	10	15	35	60	25	65
Manuring	16	24	50	80	4	5	18	25	-	16
Watering for establishment	42	-	100	-	-	-	20	-	-	-
Plant protection	3	12	15	80	2	10	8	20	-	20
Harvesting and drying	-	30	-	90	-	30	-	140	-	75
Total	254	110	610	330	115	85	211	253	238	207

identified as high yielding (20 t/ha) for *Rabi* season in rice fallows.

Elephant-foot-yam and *Dioscorea esculanta* performed well as intercrops in coconut garden yielding 30 t/ha and 8.5 t/ha respectively.

Vegetables: Short duration bush type cowpea variety 61-B and snake gourd T-19 were found high yielding during summer season (5.7 t and 15.6 t/ha respectively).

II. Animal sciences

In cross bred cattle, post-oestral bleeding was observed after 48 hrs of the onset of heat in almost every case. Insemination between 12 to 18 hrs was found to achieve satisfactory conception rate. Cashew apple waste could be economically incorporated @ 10% in diary cattle ration.

The optimum stage for rotational cutting of high yielding fodder varieties (NB 21 & BH 18) was found to be 45 days to obtain maximum digestible nutrients.

Poultry: For backyard system of poultry keeping, the cross between White Leghorn and Australorp was found suitable and economical.

To overcome Ranikhet disease vaccination stress the homoeopathic drug Thuja-1000, @ 10 ml/100 birds was found effective.

Production of parental materials and breeders' stock of plantation crops

CDO palms giving 80% hybrid recovery in CDO × WCT crosses were identified for the multiplication and for use as female parents in the seed gardens. Large scale production programme of the parental planting materials are in progress. Seedlings/seed nuts of the available exotic and indigenous cultivars and D × T hybrids of coconut produced at this Institute are being channelled to various seed gardens and co-ordinating centres in the country for enriching the parental sources. During the year 10,000 Malayan Dwarf Yellow seed

coconuts were imported from Malaysia for the Seed Garden Complex, Nilambur, and seedlings raised in individual polybags.

In arecanut, large scale multiplication of Mangala, and two other high yielding accessions-VTL-11 and VTL-17 are in progress.

In oil palm the available *tenera* hybrids produced by the Institute using the indigenous *dura* and *pisifera* were supplied to Oil Palm India for planting purpose.

The high yielding clones of cardamom were multiplied and seed capsules from the high yielding selections were distributed to farmers.

In pepper single noded rooted cuttings of Karimunda selections and Panniyur-I were raised by rapid multiplication technique and distributed to seed gardens and developmental agencies.

All India Co-ordinated Coconut and Arecanut Improvement Project

The performance of T×D coconut hybrids and Laccadive Ordinary was superior to Local Tall at Pilicode, Coimbatore, Arsikere and Ambajipeta. At Veppankulam ECT×MDY, MDY×ECT and ECT×DG were higher yielders compared to Local Tall.

At Veppankulam increase in yield of coconut (number of nuts) due to intercropping with banana (Poovan)

was 30.4% and the increase in income was Rs. 3785/ha/annum.

At Pilicode mixed cropping of coconut and cocoa (single row) gave an yield of 65 nuts/palm while palms with double rows of cocoa gave only 52 nuts and coconut pure crop gave 64.6 nuts/palm.

At Arsikere double cropping system in coconut viz., potato-wheat, French bean-wheat, ragi-wheat and chillies-wheat continued to give higher income.

At Shriwardhan for the 'band disease' of arecanut, providing drains of 60-75 cm deep and 45 cm wide at a distance of 7-9 m, application of 15-20 kg farm yard manure or compost, 150 g N, 40 g P₂O₅ and 140g of K₂O/palm/year and light but frequent irrigation were found to be the good management practices.

All India Co-ordinated Spices and Cashewnut Improvement Project

Cashew

Two hybrids, H-19/16-10 and H-26/16-18 from Cashew Research Station, Madakkathara (KAU) have an yield potential of more than 15 kg of nuts/tree/year and have bold sized nuts. These have been recommended for pre-release multiplication.

Soft wood grafting on 4-6 month old shoots emerging after coppicing, using 3-4 month old scions were found to be very successful for upgrading the unthrifty trees under west coast condition.

Cardamom

Hybrid No. 571 with bold capsules from Cardamom Research Station, Mudigere has given more than 3 kg of green capsules per plant consistently for three years. This has been recommended for inclusion in the multilocation trial, as well as for pre-release multiplication.

Transfer of technology network

Lab-to-Land Programme : Under Phase III of the Lab-to-Land Programme, a total of 479 families was adopted at Kasaragod, Calicut, Kayangulam, Vittal and Goa centres. The major thrusts in the transfer of technology were, coconut based farming systems at Kasaragod and Kayangulam, pepper based farming system at Calicut, arecanut based farming system at Vittal, and crop production and livestock improvement at Goa. Of the families adopted, eight were landless labourers, 458 marginal and 13 small farmers. All the inputs permissible under the programme were supplied to the adopted farming families.

Training of research workers, extension workers and farmers

One hundred and seventyfive trainees from different states were trained in 14 batches at Kasaragod and other centres of the Institute. In addition, nine persons from other developing countries were also given training on cashew production and plantation crops. Besides these, short training

programmes were organized for extension workers, farmers, college students etc.

Research-cum-demonstration plots : Twentyseven research-cum-demonstration plots were laid out in farmers' fields, to demonstrate the role of scientific cultivation of plantation crops in increasing productivity. The material inputs were supplied free of cost by the Institute and labour cost was borne by the cultivator.

Kisan melas and exhibitions : Kisan Melas were organized at CPCRI Research Centre, Hirehalli and ICAR Research Complex, Goa.

Films : One film on 'Oil Palm' was produced in collaboration with the Films Division, Govt. of India.

Institute's support to T & V Programmes : The Institute at present supports the T & V programme by participation of scientists in the monthly workshops in different states. Training on plantation crops production technology is imparted to the Subject Matter Specialists of different states. This year 175 officials from 10 states were trained for solving the field problems.

Publications : During the year, one technical bulletin, ten pamphlets and six extension folders covering production and protection aspects of plantation crops were prepared and distributed.

Important Recommendations to Farmers, Arising Out of Research Efforts During 1984

1. Summer irrigation with 250–500 litres of water per week with normal application of fertilizers and plant protection chemicals in root (wilt) disease affected gardens reduces the disease symptoms and increases the net production by 64% to 200%.
2. In the mildly root (wilt) affected areas of Trichur and Trivandrum districts, all the coconut palms affected by disease in the pre-bearing stage and palms in the advanced stage of the disease may be eradicated to keep the disease under check. All parts of the removed palms including bole, roots and leaves should be burnt *in situ*. Gap filling in the same pit may be avoided. The recurrence of the disease may be monitored and the affected palms if any should be removed as and when noticed.
3. Sequential application of fungicides like Bordeaux mixture (1%), Dithane M-45 (0.3%) and Fytolan (0.5%) at quarterly intervals helps in reducing leaf rot infection to the extent of 73.4%.
4. Tall × Gangabondam, Chowghat Dwarf Orange × West Coast Tall, Malayan Dwarf Yellow × Java Giant, Java Giant × Malayan Dwarf Yellow are recommended for planting in *Radopholus similis* infested areas in view of their lower susceptibility to this pathogen.
5. Placement of phorate granules (10%) in perforated polybags in the innermost leaf axil of areca palms in April is an effective management practice for maintenance of areca gardens free from infestation by spindle bugs.
6. Bunch failure in oil palm can be effectively controlled by adopting an integrated method involving crown cleaning, assisted pollination and 0.2% carbendazim (Bavistin) spray.
7. The high yielding varieties of cashew *viz.*, M 44/3, M 10/4 and BLA 139 are recommended for large scale multiplication.
8. Epicotyl grafting is suitable for large scale multiplication of cashew.

Recommendations to the Extension Agencies and Farmers of Goa

1. The high yielding short duration paddy varieties IET 6223, IET 7918 and RP 79-5 are tolerant to blast disease (yield-55 q/ha).

2. Cross-4 and Kanhangad Local are two high yielding sweet potato varieties suitable for *Rabi* season in rice fallows (yield : 20 t/ha, Goa Local – 10 t/ha).
3. To obtain better conception rate in cross bred cows insemination is to be done within 12–18 hrs of heat.
4. The cross WLH × AL (White Leghorn × Australorp) is recommended for 'back yard system of poultry keeping'.
5. A single dose of Thuja-1000 (a homoeopathic drug) @ 10 ml/100 chicks in drinking water could effectively check the post-vaccination stress and side effects in the case of Ranikhet disease. This is more economical than the conventional treatments.

