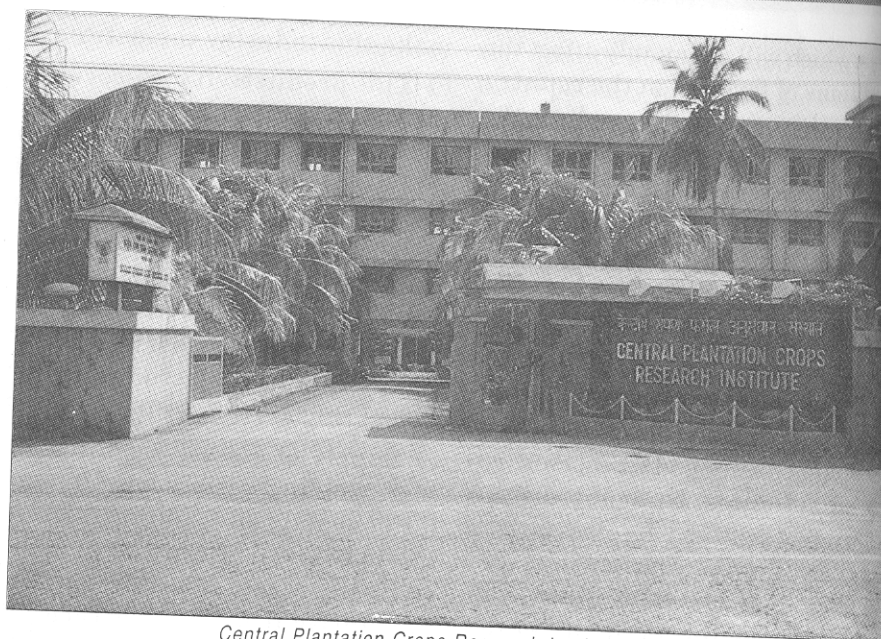


Milestones in Coconut Research

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Central Plantation Crops Research Institute (1970)

Coconut (*Cocos nucifera* L.) is one of the most important tree species cultivated in humid tropical conditions. Eulogised as the tree of heaven (Kalpavriksha), it has large number of varied uses. It has a recorded history of cultivation going back to more than 3000 years along the Malabar coast of India i.e. Kerala. The name 'Kerala' itself is suggestive of the importance of coconut in the life support system for the people of the state.

In India, coconut is mainly grown in the four southern states, which together account for more than 90 per cent of production in the country. Earlier, coconut was a subsistence crop, but, with the transformation to market economy, it is now being cultivated for economic benefits. The palm is mainly a small holder's crop that is ecologically sound and offering broad range of products and providing income and employment opportu-

nities. More than 10 million families are directly or indirectly dependent upon it for their livelihood.

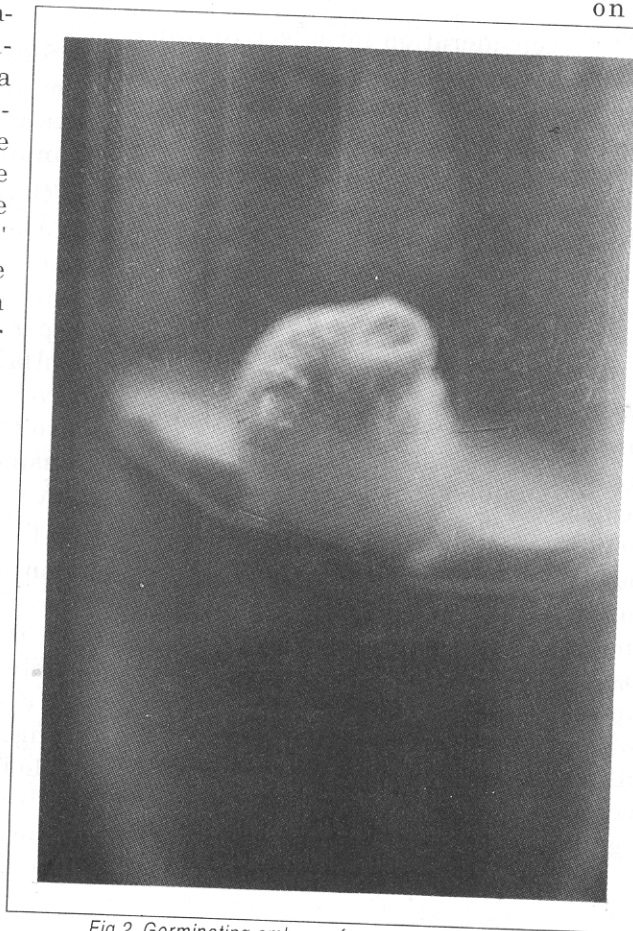


Fig.2. Germinating embryo of coconut variety Guelle Rose after 30 days (Indian Ocean collection)

Development of Research Infrastructure

The first systematic research on coconut in the world was started in India in 1916 with the establishment of four research stations in the erstwhile Madras Presidency. The four centres were established in different soil types representing coconut cultivated soils of northern Kerala. They were at Pilicode (laterite gravelly soil), at Nileshwar (two centres - red sandy loam soil and coarse sandy soil) and Kasaragod (red loamy soil). These stations functioned under Deputy Director of Agriculture, Tellichery. In 1931, these stations were put under Oilseeds Specialist, Coimbatore. J.S. Patel was appointed as Oilseeds Specialist and stationed at Coimbatore. Voluminous data gathered by Patel and his associates, particularly K.C.W.C. Marar, from 1930 onwards were published in the first Coconut Monograph titled "Coconut - a

Monograph" by J.S. Patel in 1938 (Nair *et al.*, 1996). In 1945, Indian Central Coconut Committee was set up for the improvement and development of crop. Subsequently, Kasaragod station was brought under the administrative control of Central Coconut Committee and sections on Agronomy, Botany, Cytogenetics and Analytical chemistry were established (Nair *et al.* 1996).

Root(wilt) disease, a slowly debilitating disease of coconut was first reported after great floods of 1882, in three independent locations each about 50 km apart in the erstwhile state of Travancore (Butler, 1908; Kunjan Pillai 1911; Varghese, 1934). The State Department of Agriculture (Travancore state) established State Research laboratory at Quilon and field station at Kayangulam to work on coconut diseases with added emphasis on root(wilt) disease. Realising the importance of diseases, in 1947, the two stations at Quilon and Kayangulam were transferred to Central Coconut Committee. Later on, Research Laboratory at Quilon was shifted and merged with Kayangulam in 1949. The control measures for various pests and diseases could be worked out except for root(wilt) disease at Kayangulam Station.

The work on coconut was further intensified and Kasaragod station was upgraded with CM John as its first Director in 1950. Between 1945-1955, experiments on suitable agrotechniques for coconut were initiated. The voluminous data generated from Coconut Research Stations at Kasaragod, Pilicode, Nileshtar and Kayangulam were compiled and a monograph on coconut was published by Dr. KPV Menon and KM Pandalai in 1958, which according to M.S. Swaminathan, "Does not seem to age with time" (Swaminathan, 1976).

The Indian Central Coconut Committee also took up region specific problems and adaptive research in different coconut growing tracts of the country by extending various assistance to state governments to set up research facilities. The details are given in *Table 1*.

In 1966, Indian Central Coconut Committee was abolished and ICAR took over the administrative control of Coconut Research Stations at Kayangulam and Kasaragod. In 1970, ICAR established Central Plantation Crops

Research Institute by merging the two stations at Kayangulam and Kasaragod and the Central Arecanut Research Station at Vittal along with the five Regional Stations (*Fig. 1*).

In 1970, the ICAR sanctioned the All India Coordinated Coconut and Arecanut Improvement Project with its headquarters at Kasaragod. The first workshop was held in 1971 at Kasaragod, wherein all the research programmes were finalised, and the programmes were initiated in 1972. Presently there are ten centres

Table 1. Milestones in Development of Research Infrastructure

Year	Milestone
1945	Establishment of Indian Central Coconut Committee
1947	Transfer of Kasaragod station to Committee's administrative control
1948	Establishment of Research Station at Kayangulam
1948	Establishment of Kumarakom Coconut Research Station in Kottayam Dist.
1948	Establishment of Balaramapuram Coconut Research Station at Pachallor by the State Govt.
1966	Abolition of Indian Central Coconut Committee and handing over administrative control of Kasaragod and Kayangulam stations to the ICAR.
1970	Establishment of CPCRI with Kasaragod as its headquarters merging of Kayangulam Research Station and establishment of Research Station at Sipighat (Andamans).
1971	Initiation of All India Coordinated Research Project (AICRP) on Coconut and Arecanut.
1972	Establishment of Ratnagiri, Dapoli, Razole and Veppankulam centres under AICRP and Seed Farm at Kidu under CPCRI
1975	Establishment of Arsikere, Pilicode, Mahuva, Coimbatore and Ambajipeta Centres under AICRP
1977	Establishment of Konark Centre (AICRP) and field station at Irinjalakuda under CPCRI
1980	Establishment of Mandouri Centre (AICRP)
1982	Establishment of World Coconut Germplasm Centre in Sipighat, Andamans and shifting of field station at Irinjalakuda to Trichur.
1985	Establishment of Kahikuchi Centre (AICRP)
1986	Establishment of Jalalgarh (Bihar), Jagadapur (MP) and Aliyarnagar (TN) Centres (AICRP). Closure of field station at Irinjalakuda.

viz. Ambajipeta (Andhra Pradesh Agricultural University), Kahikuchi (Assam Agricultural University), Jalalgarh (Rajendra Agricultural University), Arsikere (University of Agriculture Sciences, Bangalore), Ratnagiri (Konkan Krishi Vidyapeeth), Jagdalpur (Indira Krishi Vishwa Vidyalaya), Konark (Orissa University of Agriculture and Technology), Aliyarnagar and Veppankulam (Tamil Nadu Agricultural University) and Mandouri (Bidhan Chandra Krishi Viswa Vidyalaya) functioning as research centres for coconut under AICRP to cater to the location specific needs of the crop.

A number of universities namely, Kerala Agricultural University, Tamil Nadu Agricultural University, Andhra Pradesh Agricultural University, Orissa University of Agriculture and Technology, Bidhan Chandra Krishi Viswa Vidyalaya, Assam Agricultural University and Konkan Krishi Vidyapeeth and some state farms like Aralam Farm (Kannur) and private farms like DJ Farm are involved actively in the pursuit of research in coconut. Coconut Development Board lends financial and developmental support to provide impetus in research programmes.

Salient Achievements in Coconut Research

Notable strides in coconut research have been made in the last eight decades. These have contributed substantially towards increasing the production and productivity of coconut. It is worth mentioning the important achievements which emerged from the pioneering work done by different research/developmental institutions.

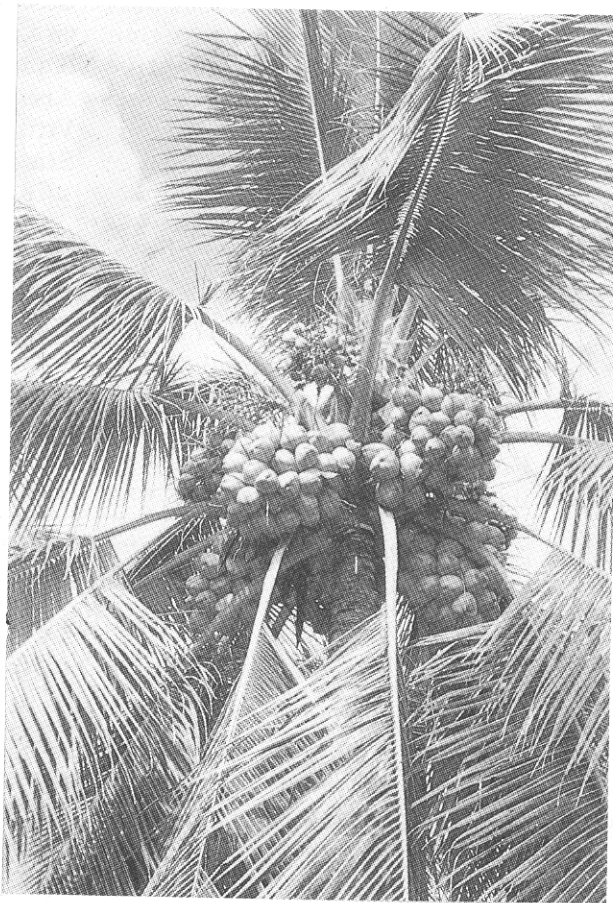


Fig.3. Kera Sankara (WCT x COD) hybrid released from CPCRI

A) Crop Improvement

Collection, conservation and cataloguing of coconut germplasm was accorded the top priority in the coconut research. The first exotic materials were collected during 1924 from Philippines, Malaysia, Fiji, Indonesia, Sri Lanka and Vietnam, which formed the nucleus for further research programmes. During 1940, the first germplasm bank was started at the erstwhile Central Coconut Research Station, Kasaragod (presently, CPCRI Kasaragod). The programme on indigenous germplasm collection was initiated in 1952 and the first indigenous survey for germplasm collection was started in 1958. Later on, in 1981, under the FAO/IBPGR funded expedition, 24 exotic collections were made from six Pacific Ocean countries. These are

being maintained at World Coconut Germplasm Centre, Andamans. At present, the Institute has the world's largest germplasm collection comprising of 132 accessions of coconut (46 indigenous and 86 exotic). It is difficult, cumbersome and costly to transport nuts from distant places abroad to India. Embryo culture technique has been standardised (Anitha Karun *et al.* 1993) and have proved very useful in field collection from Indian Ocean Islands. Short term storage of coconut embryos in Y3 basal medium was also standardised at CPCRI. Recently, the coconut germplasm has been further strengthened by a recent collection of 15 exotic accessions from the Indian Ocean Islands (6 from Mauritius, 4 from Madagascar and 5 from Seychelles) using embryo-culture technique for the

first time in the World with a success rate of 96 per cent (Koshy & Kumaran, 1997) (Fig. 2).

Germplasm is also being maintained at Pilicode (Kerala Agricultural University) and four Coordinating Centres *i.e.* Veppankulam (Tamil Nadu), Arsikere (Karnataka), Ambajipet (Andhra Pradesh) and Ratnagiri (Maharashtra).

Systematic multilocation evaluation of indigenous cultivars led to release of four cultivars viz. Laccadive Ordinary, Philippines Ordinary, Chowghat Orange Dwarf and Pratap for cultivation. Chowghat Orange Dwarf has been identified as the best cultivar for use as tendernut.

The hybrid vigour in coconut was first exploited by Dr. J.S. Patel by crossing the local West Coast Tall with the Chowghat Green



Fig.4. Coconut based high density multispecies cropping system

Dwarf and the hybrids were planted in 1934 for evaluation. The first hybrid plantation in the world even today stands as a monument at the present Agriculture Research Station, Nileshwar. Eversince, a number of hybrids involving Tall and Dwarf have been evaluated for their increased productivity. In India till date, 11 hybrids have been released for cultivation. Chandra Sankara (COD x WCT), Kera Sankara (WCT x COD) (Fig. 3) and Chandra Laksha (LO x COD) coconut hybrids released from CPCRI gave 49 to 77 per cent more copra yield over local tall. These hybrids are not only early bearers but also give higher yield than either of the parent. A coconut seed garden was established at Kidu (Karnataka). Seed gardens were also set up in Ettankulam (Tamil Nadu), Nilambur (Kerala) and Navlok (Karnataka) to increase hybrid seed production.

B) Crop Management

Agronomic trials conducted during forties and fifties helped to determine the optimum manurial and cultural requirements of co-

conut palm. In 1972, a general recommendation was given from CPCRI for fertilising the adult bearing palm advising to apply 500g N, 320g P₂O₅ and 1200 g K₂O/palm/year in two split doses namely one-third of the above dosage during May - June (pre-monsoon) and two-third during September - October (after cessation of rains) (Nelliath, 1972).

On evaluation of different phosphate carriers, rock phosphate was recommended as ideal source of P for coconut as the soil receiving rock phosphate gave the best reflect on plant P and enriched all P fractions in the soil and influenced overall yield (Khan *et al.* 1985). Further, Khan *et al.* (1992) observed that withholding application of phosphatic fertilisers for 14 years did not affect the yield and nutrition of adult coconut palms. It is now advocated that P application can be skipped if the soil available P is above 20 ppm.

Spacing trials have shown that a plant density of 175 palm/ha with a spacing of 7.5 x 7.5 m was optimum under rainfed conditions.

Coconut being a widely spaced crop, can support diversified needs of food, fodder and fuel apart from increasing the net return per unit area, by practising various farming/cropping systems (Fig. 4). The first systematic trial on cropping system was laid out in 1972 at CPCRI. Scientists have developed many compatible crop combinations which can be suitably grown in the interspaces by efficient utilisation of soil and air space in the garden without effecting the yield of main crop while realising higher net returns to the farmers. A number of annuals like vegetable crops viz. brinjal, snakegourd, chilli, amaranthus etc., pulses like green gram, blackgram, redgram, etc., fruit crops like banana and pineapple, tubercrops like cassava, elephant footyam and rhizomatous spices like turmeric and ginger and perennials like cocoa, clove, nutmeg, pepper, jackfruit, breadfruit, etc. have been successfully tried in the coconut garden. Apart from this, as part of mixed farming system in coconut, rabbitry, dairy, poultry and pisciculture has been successfully tried at CPCRI.

Evaluation of different nursery techniques for raising coconut seedlings revealed that sowing in potting mixture medium (sand: red earth: FYM in 1:1:1 ratio), either in polybag or cement tank is beneficial in producing vigorous seedlings and also to get higher recovery (CPCRI Research Highlights 1997-98).

Irrigating palms through drip system was found to be more advantageous in both littoral sand as well as laterite soils. Six emitters per palm in littoral sand and four emitters per palm in laterite soil were found to be optimum for supply of water in the root region. Irrigating palms with 66 per cent of Eo (32 ltr/palm/day) was sufficient to produce yield on par with ba-

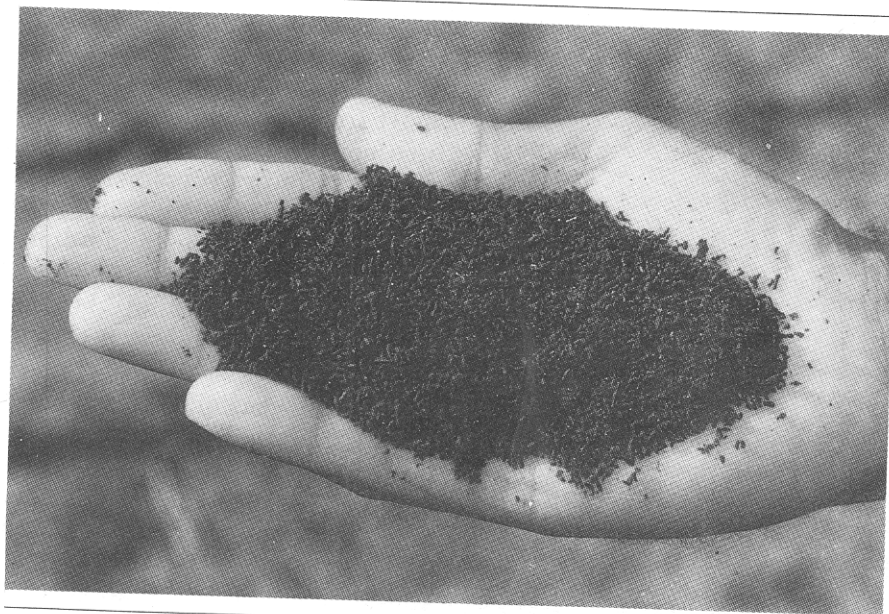


Fig.5. Vermicompost from coconut wastes

sin irrigation (200 ltr. once in four days) in both littoral sand and laterite soil (CPCRI Research Highlights 1997-98).

Coconut produces large quantity of waste/byproduct annually. It is estimated that approximately 11.2 million tonnes of dry fronds and sheddings (Biddappa *et al.* 1996) and 7.5 million tonnes of coirpith (Kamaraj, 1994) are available annually which if left in field will cause environmental problems. A low cost technology for the large scale production of vermicompost from coconut plantation wastes has been standardised and successfully demonstrated using a large, pigmented and active local epigeic earthworm species at CPCRI. In 75 days, the whole procured coconut palm wastes except midribs of leaves get converted into odourless and granular pure vermicasting (Fig. 5) having a C:N ratio of 9.95 and recovery as high as 70 per cent (CPCRI Research Highlights 1997-98).

For WCT palms in red sandy loam soils along the west coast, perfo irrigation of 20 mm of water, when cumulative pan evaporation reaches 20 mm was found

to be the best irrigation schedule (Yusuf *et al.* 1994).

Coconut hybrids like LO x GB, LO x COD and WCT x COD and Talls like LO and WCT have been identified as relatively drought tolerant compared to other varieties/hybrids (Rajagopal *et al.* 1990).

C) Crop Protection

a) Diseases:

The root(wilt) disease has been found to be endemic in a contiguous area of eight districts of southern Kerala. Survey conducted on crop loss in 1984-85 by CPCRI in association with the Department of Agriculture, Kerala and other agencies revealed the prevalence of the disease in about 4,10,000 ha and intensity of disease varied from 1.5 per cent in Thiruvananthapuram to 75.6 per cent in Kottayam district with an annual yield loss of 968 million nuts (Anonymous, 1985).

Root(wilt) disease cure continues to be an enigma for researchers to this day. The Electron Microscopy work done at CPCRI has conclusively established *Phytoplasma* as the causative agent of

this disease (Solomon *et al.* 1983). Successful transmission of the disease with lace bug (*Stephanitis typica*) and plant hopper (*Proutista moesta*) has been done, thereby establishing the phytoplasmal etiology of this disease. Indices for measuring disease severity have been developed for root(wilt) disease of coconut.

No cure for root (wilt) exists till date. The alternative to this is development of disease resistance/tolerant cultivars. As early as in 1972, field tolerance of Chowghat Green Dwarf palms to root (wilt) disease have been reported (Anonymous, 1971). Subsequently, 19 CGD and 26 WCT palms have been identified as disease free palms for the breeding programme based on the serological and physiological tests (Iyer and Dhamodaran, 1994). A programme for evolving disease tolerant varieties initiated at CPCRI Regional Station, Kayangulam since 1987 with disease free healthy palms in the disease endemic areas has started bearing fruitful results and the hybrid involving such palms and CGD field planted in 1991 are showing symptoms of tolerance (Fig. 6).

A number of management strategies have been tried which have given good results in disease early to medium index palms. Cultivation of forage grasses in the interspaces of diseased coconut plantations and recycling of cattle manure and other organic wastes in the garden resulted in decrease in foliar yellowing and increase in nut yield by 26.1 per cent over a period of five years (Sahasranaman *et al.* 1983). The response was higher in disease early palms and lowest in disease advanced palms. As an integrated approach to eradicate root(wilt) disease on a large area basis and to increase productivity of coconut, CPCRI in collaboration with KAU, Dept. Of

Agriculture, Kerala, FACT and Indian Overseas Bank, Varanderappally branch implemented a scheme in 1980-81. It has been recommended to remove all heavily infected and unproductive palms and all juvenile diseased palms in areas of severe incidence.

The stem bleeding disease was first reported in 1922 in India. *Thielaviopsis paradoxa* has been established as the primary causal agent for this disease. Application of Calixin (5 per cent suspension) through root feeding (June, October and January) and wound dressing (October) along with the application of 5 kg of neem cake per palm per year has been recommended. Antagonistic fungi belonging to *Trichoderma* species viz. *T. harzianum*, *T. hamatum* and *T. viride* and *Gliocladium virens* have been identified and field evaluated for their successful control of this disease (Ramanujam *et al.* 1997). Techniques for mass production of these biocontrol agents have been standardised for soil application.

The Thanjavur wilt disease was reported first in Thanjavur district of Tamil Nadu in 1952 and (now is found in Andhra Pradesh, Tamil Nadu, Karnataka as well as border districts of Kerala. *Ganoderma lucidum* and *G. applanatum* are associated with the disease. Phytosanitation and isolation of the disease affected palms by digging trenches, root feeding with Calixin and drenching the soil with 1 per cent Bordeaux mixture along with application of neem

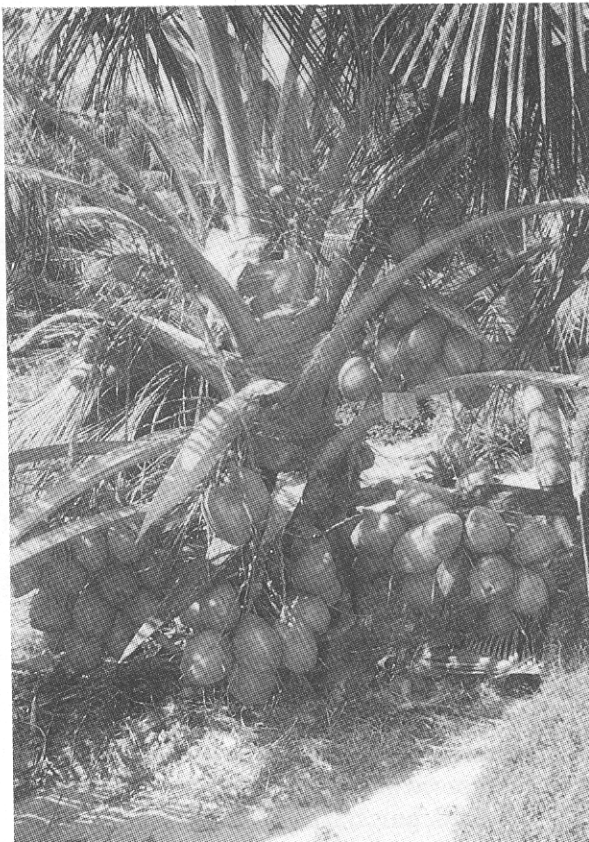


Fig. 6. Root(wilt) disease tolerant hybrid planted at CPCRI, Kayangulam



Fig. 7. Crown choking disease of coconut

cake @ 5 kg/palm/year are the existing recommendations for controlling the disease (Bhaskaran *et al.* 1994).

Crown choking disease (Fig. 7) due to boron deficiency is generally prevalent in Assam and West Bengal (Baranwal *et al.* 1989). A survey conducted in Assam showed 10.8 per cent of the palms affected by this disease and the total annual loss was estimated at 6.38 million nuts (Anonymous 1990). However, the pockets of deficiencies are also being reported in Kerala, Goa and other states. Application of Borax @ 100g/palm/year at half yearly intervals is effective in controlling this disease.

b) Pests

Regular outbreaks of black headed caterpillar, *Opisina arenosella* are noticed in coastal areas of Malabar and Dakshina Kannada District. First outbreak of this pest in India was reported in 1990 from Bapatla and subsequently research initiated in 1929. An integrated pest management strategy encompassing cutting and burning of severely affected leaflets and spraying of Dichlorovos @ 0.2 per cent on the foliage and after two weeks of release of larval parasites *Goniozus nephantidis* and *Bracon brevicornis* followed by *Brachymeria nosatoi* have been found effective for the successful control of this pest (Fig. 8a & 8b).

Another important pest of coconut is rhinoceros beetle. This can be controlled by adopting integrated management practices involving hooking the beetle, leaf axil



Fig.8a. Severe infestation of coconut palms by leaf eating caterpillar (*Opisina arenosella*)

filling with sevidol (25 g) and fine sand (200g) and releasing Baculovirus infected beetles and treating the breeding sites with *Metarhizium anisoplaea*. Likewise, coconut white grubs can be controlled by applying Phorate @ 100g/palm during pre and post monsoon periods. In 1998, Eriophyid mite has emerged as a serious problem in Southern Kerala.

D) Pre and Post Harvest Technology

Coconut waste has been successfully used for oyster mushroom cultivation (Fig. 9). Higher biological efficiency of 60 per cent has been achieved in coir pith by using a fermentation technique for coir pith followed by cultivation of *Pleurotus eous* (APK-1) and *P. ostreatus*.

A number of pre and post harvest devices have been developed. Electrical and solar driers for copra making with a capacity to dry 1000 and 100 coconuts have been fabricated. In CPCRI, an indirect type copra dryer of 400 nuts per batch capacity using agricultural waste as fuel was developed. It consists of a drying chamber, plenum chamber, burning cum heat

exchanging unit and a butterfly valve to control the rate of combustion and also the drying air temperature. The drying time required per batch was 36 hours spread over 4 days (Patil, 1984). So far, more than 100 units of this dryer have been sold to various copra makers and satisfactory performance is reported.

Preservation of fresh kernel becomes essential when drying is

delayed due to uncertainty of weather conditions. A chemical treatment of dipping fresh kernel in 1000 ppm propionic acid for 60 minutes to preserve it upto 4 days without further drying has been developed. This was found to be useful and simple to overcome the spoilage of kernel due to sudden onset of inclement weather (Patil *et al.* 1980).

Freshly cut coconut trunks from senile coconut trees and disease advanced palms in root (wilt) affected areas can be used as timber for purposes like electric poles, telecom poles and for interior uses such as to make furniture, window and door frames, if treated with preservatives, to increase its shelf life. Research work is in progress at CPCRI in this field (Fig. 10). Philippines has already developed a technology known as HPSPD (high pressure sap displacement) treatment. It is a process of preserving the strength and durability of freshly felled trees by forcing out the sap from the trunk using a waterborne preservative solution. This process uses a high pressure sap displacement apparatus.



Fig.8b. Palms recovered after using control measures for leaf eating caterpillar (*Opisina arenosella*)

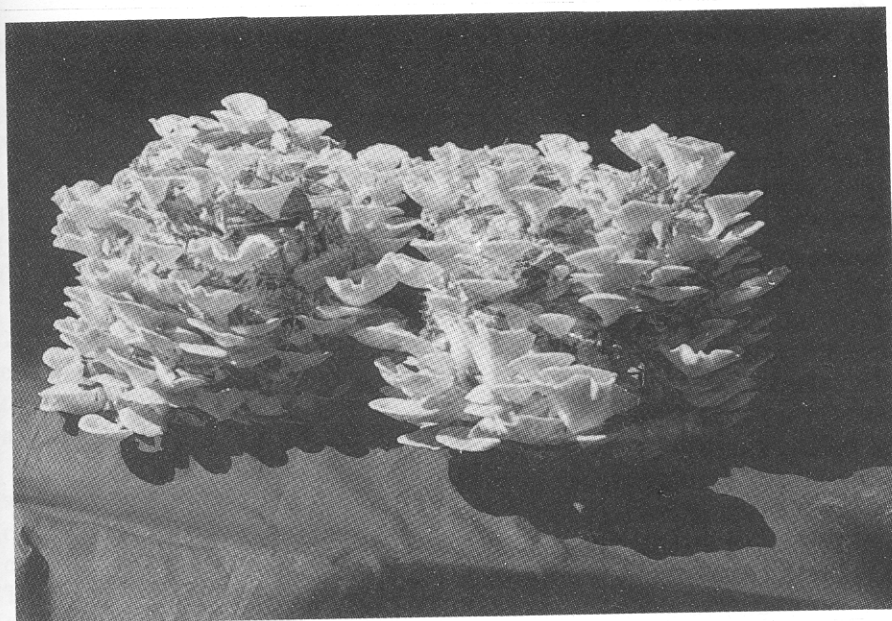


Fig. 9: Oyster mushroom production in coconut waste

The moisture level in copra in the range of 5 to 40 per cent can be determined by using an electronic moisture meter.

An automatic irrigation system suitable for all high frequency irrigation systems has been developed (Fig. 11). When installed in field, it gave 90 litres of water per palm in two days when tensiometer is set at 0.2 atm. The approximate cost of the system is Rs.2000 excluding the cost of irrigation system.

Another gadget in use is a telescopic coconut bunch support system. Kerala Agricultural University, Thavannur has fabricated a simple, cheap and efficient dehusker.

Future Thrust

As briefed in the preceding text, great strides have been made in this crop, inspite of it being perennial in nature with long gestation period. Still there are areas where either no information is available or it is too meagre to be utilised on a practical level. The following are the major areas which requires attention to catapult the country in coconut research in the 21st century:

i) Root(wilt) disease still confounds the researchers in finding a final remedy. There is urgent need to tackle it further by intensification of research using biotechnological tools to identify the molecular markers linked to genes conferring resistance. This will be helpful in the early diagnosis which can be later on used for selection of resistance/tolerance of population.

ii) Now the art of field collection, storage and retrieval of coconut zygotic embryos have been perfected and used suitably for collection of germplasm from Indian Ocean Islands. Encapsulation of embryos to get synthetic seeds and possibility of cryostorage under ultra low temperature indicates the feasibility of establishing a Cryogenic gene bank for long term conservation of coconut germplasm. (CPCRI Perspective Plan, Vision 2020).

iii) A number of hybrids have been released for commercial cultivation. However, the existing planting material production is not at all enough to bridge the gap between supply and demand for elite planting materials. Hence, there is a need for increasing the capacity for increased production of planting materials.

iv) All efforts have proved futile in developing protocol for somatic embryogenesis. However, continued efforts are required in this area for large scale production of planting material especially of disease resistant/tolerant materials in the endemic areas of root(wilt) disease and for multiplication of

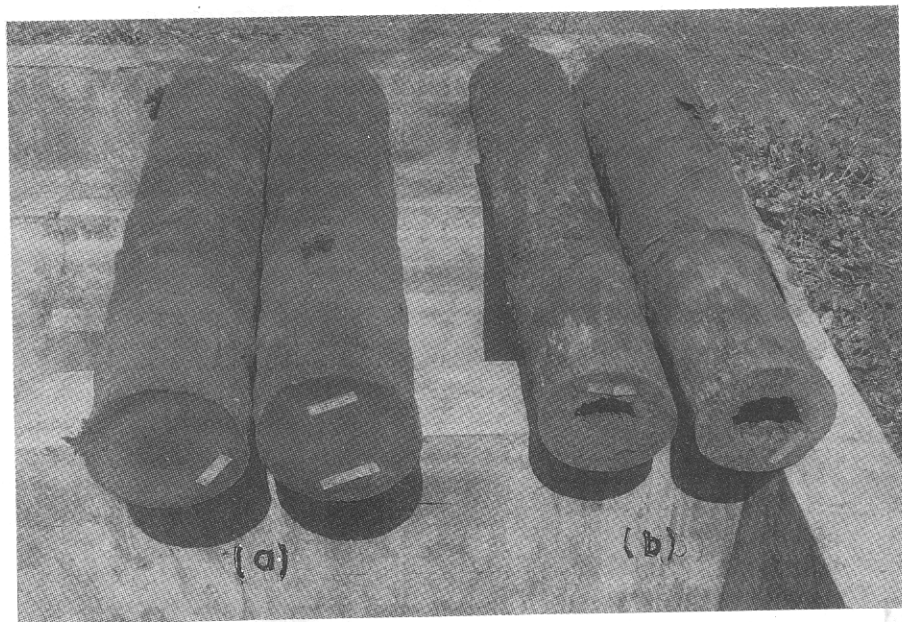


Fig.10: Coconut timber processing - (a) Untreated coconut logs (b) Creosote treated logs.

elite/super palms as coconut is a highly cross pollinated crop.

v) Physiological evaluation of coconut varieties for photosynthetic efficiency, water and nutrient use efficiency and dry matter production/partitioning will be priority areas of research to realise the maximum potential of the crop (CPCRI Perspective Plan, Vision 2020).

vi) Requirement of fertiliser prescription models requires understanding of several integrated factors such as behaviour of applied and soil forms of nutrients in the yield production processes. There is a need to develop a computer simulation model based on large data base incorporating the nutritional variability and its relationship with yield where the nutrient requirement is diagnosed by studying the current nutrient status of soil and foliar levels (CPCRI Perspective Plan, Vision 2020).

vii) No systematic studies have been carried out on secondary and micronutrient nutrition in coconut till date. There is a need to reorient nutritional application strategy (which is now based on NPK alone) taking into account other nutrients.

viii) Cross inoculation studies in coconut, arecanut and oilpalm have given some interesting lead regarding phytoplasmal transmission. The efforts in this direction is all the more important as these crops are grown in same agroclimatic region and more or less in contiguous areas.

ix) A comprehensive survey to cover Thanjavur wilt and Tatipaka disease of coconut palm is required to collect information on the spread of diseases as well as crop loss.

x) Screening of new pesticide formulations, studies on insecticide residues, studies on genetical

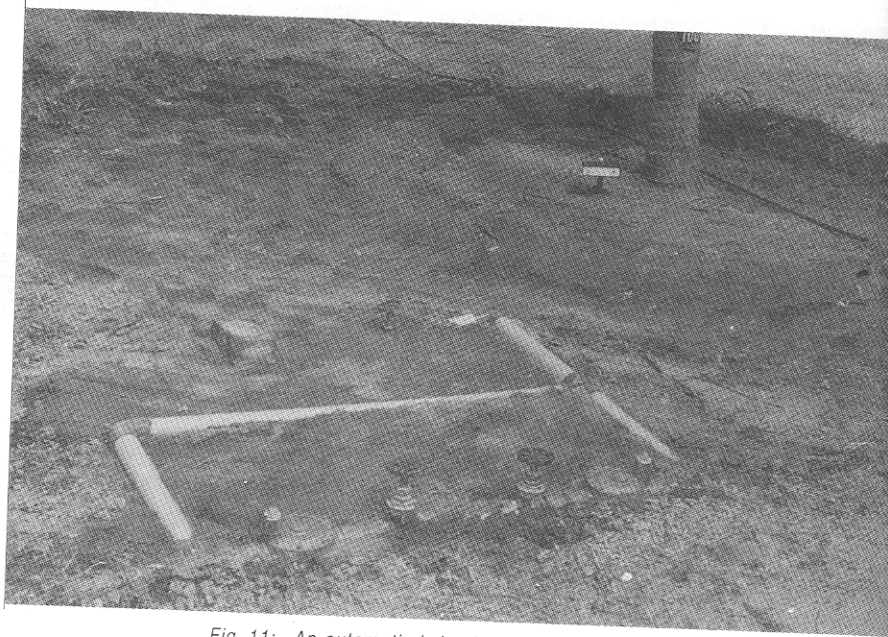


Fig. 11: An automatic irrigation system installed in field

method of pest control, use of pheromones and identification of efficient botanical pesticides will be special programmes on the pest management of coconut in addition to biological pest suppression (Nair *et al.*, 1996)

xi) Product diversification is an important area needing attention in India in view of the fierce competition in international market for coconut oil.

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