Status of Coconut Research & Development in India, Malaysia, Sri Lanka and Tanzania

'KERAGANGA' (West Coast Tall X Gangabondam) identified by the Kerala Agricultural University during 1987-88 for release in the Kerala State, India for general cultivation - Adaptable for successful cultivation under rainfed conditions - Age at first flowering: 5 years - Mean nut production/palm/year: 100.20 - Highest nut production: 220/palm/year - Mean copra yield/palm/year: 20.14 kg.

Status of Coconut Research & Development in India, Malaysia, Sri Lanka and Tanzania

Brought out on the occasion of the
NATIONAL SYMPOSIUM
ON
COCONUT BREEDING AND MANAGEMENT
held at Vellanikkara, Trichur, Kerala, India
during 23-26 November, 1988
Organised by the
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Department of Bio-Technology, Govt. of India, New Delhi
Kera Karshaka Sahakarana Federation (KERAFED), Trivandrum
Kerala State Coconut Development Corporation, Trivandrum,
State Committee on Science, Technology and Environment (STEC)
Trivandrum-695 001
and
State Department of Agriculture, Kerala.

STATUS OF COCONUT RESEARCH & DEVELOPMENT IN INDIA, MALAYSIA SRI LANKA AND TANZANIA

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FOREWORD

The coconut palm *Cocus nucifera* Linn. is one of the most useful and beautiful trees in the world which provide food, livelihood and shade for millions of people in the tropical areas. The tree is looked upon with reverence and affection and is referred to by such eulogistic epithets as *Kalpa vriksha* ('Tree of Heaven') and the 'Tree of life'.

The Philippines and Indonesia are the world's largest producers of coconut. India ranks third on the world map of coconut with an area of about 1.2 million hectares and the annual production of 6620 million nuts. The present level of average productivity of nuts is as high as 62 in Western Samoa and 45 in Sri Lanka while in India this is only 38/palm/year. In India, coconut has continued as a deficit commodity for long. The projected annual demand in the country is 9359.4 million nuts by the end of the year 1990. The present level of availability is only 6620 million nuts in India. Unless substantial increase in production and productivity of coconut take place by quantum leaps, it would be difficult to bridge the above gap within a reasonable period of time. Replanting unproductive and badly diseased palms with selected hybrids and ensuring integrated management practices on a wider scale are essential for increasing production and and productivity of the crop.

It was the pioneering studies and effortsof Dr. J. S. Patel, the Oil Seeds Specialist of the erstwhile Madras presidency, which led to the establishment of the first ever hybrid coconut plantation of the world. This plantation was established in 1938 with Tall X Dwarf hybrids in the Coconut Research Station, Nileshwar, now under the Kerala Agricultural University.

The successful establisnment of the hybrid coconut plantation at Nileshwar gave impetus to the development of several hybrid varieties in India and elsewhere. Hybridization has now become a major activity for coconut improvement.

In peninsular India, the hybrids such as Laksha Ganga (LO X GB), Anantha Ganga (AO X GB), Chandra Shankara (CDO X WCT) and Laksha Shankara (LO X CDO) have become quite popular. The other popular hybrids include MAWA in Malaysia, MAYPAN in Jamaica and MYD X WAT in Tanzania.

To commemorate the Golden Jubilee of the establishment of the first ever hybrid coconut plantation in the Nileshwar centre, the Kerala Agricultural University had decided to organise a National Symposium on Coconut Breeding and Management at the Vellanikkara campus during 23-26 November, 1988. This Symposium is co-sponsored by the Central Plantation Crops Research Institute (ICAR), Kasaragod; Coconut Development Board; Council of Scientific & Industrial Research, (CSIR); Department of Bio-Technology, Govt. of India; Kera

Karshaka Sahakarana Federation (KERA-FED); Kerala State Coconut Development Corporation; State Committee on Science, Technology & Environment (STEC) and the Kerala State Department of Agriculture. The Development of promising hybrid varieties possessing innate resistance to major diseases and formulation of proper management techniques have become very relevant in the light of the occurrence of several devastating diseases such as the root (wilt) in Kerala, India; lethal yellowing in Jamaica, Mexico and Florida and the lethal disease in Tanzania.

The pre-symposium publication on the status of R & D in coconut in India, Malaysia, Sri Lanka and Tanzania is brought out to provide information on the progress, problems, constraints, research gaps and breaches as well as developmental needs of the crop in these countries.

The Status Reports from Philippines, Indonesia, Papua New Guinea, Jamaica and Thailand have not yet reached us for inclusion in this volume.

I hope that this publication would prove to be of value for all those who are concerned with the R & D work on coconut.

Dr. E. G. SILAS
Vice-Chancellor
Kerala Agricultural University

Vellanikkara
7-11-1988

PREFACE

Coconut is a tree of such great diversity of uses that in areas where it is grown, the economic well being of bulk of the population depends on this valuable crop. Hybridization involving Tall and Dwarf palms for varietal improvement was first attempted by Dr. J. S. Patel at the Coconut Research Station, Nileshwar, where the world's first ever hybrid plantation was established in 1938. This plantation is still maintained in this centre. The development of hybrid varieties with precocity in bearing and with substantially higher nut production is a major breakthrough in the varietal improvement work of coconut. To commemorate the golden jubilee of the first ever hybridization of coconut at the Nileshwar centre which is now under the Kerala Agricultural University, a National Symposium on Coconut Breeding and Management has been organised to be held at Vellanikkara from 23 to 26 November, 1988.

This pre-symposium publication owes its origin to the initiative of Dr. E.G. Silas, Vice-Chancellor, Kerala Agricultural University and is brought out to focus attention on the status of R & D work on coconut in India, Malaysia, Sri Lanka and Tanzania so that the developmental problems, constraints and the research gaps could be discussed by the delegates during the symposium to take appropriate decisions on the follow-up action The status reports from Philippines, Indonesia, Papua New Guinea, Jamaica and Thailand have not yet reached us for inclusion in this volume. There is a great need for similar publications on coconut, relating to different coconut growing areas of the world. The organisers wish that the present publication would serve as a harbinger for a series of such country status reports.

The organisers of the symposium express their gratitude to Mr. P. K. Thampan of the Coconut Board, Cochin, India; Goh Hock Swee of the MARI Research Station, Kluang, Malayasia; Mr. Ranjith Mahindapala, Coconut Research Institute, Lunuwila, Sri Lanka and Mr. E. N. Balingasa of the National Coconut Development Programme, Dar es Salam, Tanzania for contributing status papers for their countries.

The colour photographs for the cover pages have been provided by the Coconut Board, Cochin - 11, for which the organisers are grateful.

We also appreciate the pains taken by M/s Lumiere Printing works, Trichur-20 in bringing out this publication in the short time available at their disposal. The organisers also wish to express their gratefulness to M/s Print India, Cochin-35 for the execution of the cover printing work.

Dr. M. ARAVINDAKSHAN
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Vellanikkara
7-11-1988

THE COCONUT PROFILE OF INDIA*

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PRODUCTION AND PRODUCT UTILISATION

General

Coconut is a crop of great antiquity in India. It has a recorded history of over 3000 years and has always been an object of reverence in the local tradition. India is one of the largest coconut producing countries of the World. With an area of about 1.2 million hectares and an annual produciion of 6,620 million nuts, the country ranks third on the world map of coconut. The relative position of the country in the world is given in Table-1.

Table:-1. Area under cultivation and production of coconuts in the different coconut growing countries of the world (1985)

Country	Area (in '000 hectares)	Percentage share	Production (in million nuts)	Percentage share	Yield per hectare	No. of nuts per ton of copra
Philippines	3,275	32.7	10,749	27.2	3,282	4,500
Indonesia	3,060	30.6	9,050	23.0	2,958	4,500
India	1,209	12.1	6,620	16.8	5,474	6,800
Sri Lanka	419	4.2	2,958	7.5	7,060	4,925
Papua New Guinea	241	2.4	1,255	3.2	5,207	5,500
Malaysia	315	3.1	1,165	2.9	3,698	5,270
Thailand	402	4.0	706	1.8	1,756	4,450
Vanuatu	69	0.7	402	1.0	5,826	NA
Western Samoa	42	0.4	248	0.6	5,905	5,300
Solomon Islands	63	0.6	209	0.5	3,317	4,500
Palau	14	0.1	70	0.2	5,000	NA
F. S. Micronesia	14	0.1	60	0.2	4,286	NA
Others (Approx)	900	9.0	6,025	15.1	NA	NA
Total	10,023	100.0	39,517	100.0	—	—

NA=Not available

* Reproduced from the author's publication "Glimpses of Coconut Industry in India" published by the Coconut Development Board, Cochin 682 011, pages 1-30.

Although India is one of the largest coconut producing countries of the world, the per capita availability of coconut is as low as 10 nuts per year, whereas it is as high as 208 nuts in the Philippines, 53 nuts in Indonesia and 124 nuts in Sri Lanka. Apart from the population factor in India, an important reason for this situation is that coconut is not grown in all the states of the country, but is confined to the coastal states which ultimately have to meet the entire domestic demand. Even among the coastal states, there is regional imbalance in the distribution of the crop. As much as 57 per cent of the total coconut area is concentrated in Kerala, a small state accounting for only 1.18 per cent of the total land area of the country. The central and north eastern belts of the country are not favoured with congenial conditions for coconut culture on commercial lines. However, favourable locations are available in many states in these belts for tne successful introduction of coconut. The crop is slowly becoming popular in these centres and extensive areas suitable for the purpose have already been identified. The differential distribution of coconut in the country is shown in Table-2.

Unlike other commercial crops grown in the country, coconut is essentially a small holder's crop. It is grown mostly in homestead gardens and small holdings. There are about 5 million coconut holdings in the country with 98 per cent of such holdings occupying below two hectares. In Kerala State alone, there are about 2.5 million holdings. Details of the size of coconut holdings in the country are given in Table-3.

The post-harvest operations and the processing industries which have grown around the crop are important sources of revenue and employment to the country. It is estimated that about 10 million people depend directly or indirectly on coconut culture and industry for their

Table-2: The distribution of coconut in India

State	Area in '000 hectares	Percentage share	Production in million nuts	Percentage share
Kerala	687.5	56.8	3,148.6	47.5
Tamil Nadu	159.4	13.2	1,518.1	22.9
Karnataka	202.8	16.8	1,050.0	15.9
Andhra Pradesh	47.4	3.9	196.1	3.0
West Bengal	15.3	1.3	169.7	2.6
Orissa	27.6	2.3	134.9	2.0
Goa, Daman & Diu	22.9	1.9	106.3	1.6
Maharashtra	10.6	0.9	99.3	1.5
Assam	8.0	0.7	57.4	0.9
Andaman & Nicobar Islands	20.8	1.7	96.6	1.5
Lakshadweep	2.8	0.2	24.2	0.4
Pondicherry	1.6	0.1	16.7	0.2
Tripura	2.7	0.2	2.1	0.0
All India	1,209.4	100.0	6,620.0	100.0

Table-3: Size of coconut holdings in India

Size of holding (in hectares)	Percentage of holdings of different sizes			
	Kerala	Tamil Nadu	Karnataka	Andhra Pradesh
Less than 0.2	37.1	69.1	52.5	56.5
0.2 - 1.0	52.8	26.0	42.9	41.7
1.0 - 2.0	7.9	3.2	3.6	1.8
2.0 and above	2.2	1.7	1.0	—

livelihood. The crop has profound influence on the agricultural economy of many states, particularly Kerala. In Kerala, coconut is the mainstay of the people with the entire fabric of rural economy having closely woven around it. The contribution of the crop to the annual income of the State is around 15 per cent and to the agricultural income around 35 per cent. The processing industries and other activities provide direct employment opportunities to over a million people in the State and also sustain inter-state trading in coconut makes a significant contribution. The average value of production of the crop is around Rs. 13.000 million and the export earnings around Rs. 300 million, mainly through the export trade in coir and coir products.

Productivity of coconuts

As could be seen from Table-1, the per hectare yield of coconut is comparatively not high in India. The per palm yield of nuts and the unit output of copra are also low. While the average per palm productivity is 38 nuts in India, it is as high as 62 nuts in Western Samoa, 45 nuts in Sri Lanka, 40 nuts in Indonesia and 35 nuts in the Philippihes. Similarly, while only 4500 to 5000 nuts and 20,000 or evan less whole shells are required in other countries to produce one tonne of copra and charcoal respectively, the corresponding figures for India are 6800 nuts and 30,000 or more whole shells. Likewise. countries like Sri Lanka and Philippines could produce nearly 25 per cent more fibre from a unit quantity of husks compared to Kerala and other states in India. The major factor responsible for this disparity is the inherent characteristic of the cultivar 'West Coast Tall', commonly grown in India, producing comparatively small sized nuts with low copra output per nut.

Among the coconut growing states in India, there is wide variation in the productivity (Table-4). Though Kerala is the major coconut producing state, the unit productivity of the crop is low compared to that in other states.

Not only the per hectare productivity is low, but the per palm productivity is also the lowest in Kerala. According to the 1985-86 estimates, the per palm productivity in Kerala is only 33 nuts as against 44 nuts in Tamil Nadu and 54 nuts in Karnataka. In Tamil Nadu and Karnataka, coconut is predominantly an irrigated crop. In Karnataka, wherever unirrigated crop is grown, the holdings are located in valleys or near tanks where copious ground water supply is available within the easy reach of palm roots. Irrigation is not a common practice in Kerala. In holdings where irrigation is

Table-4: Productivity per hectare of coconut holding in the different states of India

(Nuts per hectare)

Year	Kerala	Tamil Nadu	Karnataka
1975-76	4,964	9,996	5,073
1976-77	4,817	10,054	5,227
1977-78	4,533	9,462	5,204
1978-79	4,900	10,258	5,215
1979-80	4,563	10,235	5,198
1980-81	4,558	11,676	5,190
1981-82	4,509	11,925	5,202
1982-83	4,721	9,969	5,204
1983-84	3,814	9,979	5,207
1984-85	5,023	10,989	5,173
1985-86	4,580	9,524	5,178

practised, the productivity is far higher than the general level and is also comparable to that of the best maintained garden in other states. Lack of irrigation facilities and the inadequate attention given ere undoubtedly the limiting factors responsible for the poor performance of coconut crop in Kerala. Another factor is the prevalence of the devastating disease commonly referred to as the root-wilt disease of cocount. In a recent sample survey conducted in 1984 for ascertaining the actual spread of the disease and the loss consequent on the incidence, it was found that nearly 30 million palms were affected by the disease, out of the total 154 million palms in the State. The disease is rampant in the southern districts of the State and the virulence is most severe in isolated holdings, where in some cases 70 to 75 cent of the palms may be affected.

But it is interesting to observe that despite the incidence of disease in the southern districts of Quilon, Alleppey, Kottayam, Ernakulam, Idukki and Trichur, the per palm productivity in these districts has been consistently on a par with that of the disease free northern districts of Malappuram, Calicut, Cannanore and Palghat. Even in Trivandrum district, which is a comparatively disease free region, the productivity is not very much different from that of the disease affected districts (Table-5).

In the northern region of the State, disease cannot be considered as the major factor responsible for the low yield. In this region, the differential performance could be attributed only to the pattern of distribution of rainfall and the low coverage under irrigation. The yield data from the disease affected districts indicate that even in the presence of disease, the average productivity of the palms could be maintained at a satisfactory level. In most of the disease affected districts, the distribution of rainfall is fairly well spread, the ground water is more favourably located and the general management practices are comparatively more intensive than in the disease free northern districts of the State. These observation also highlight the importance of irrigation and other management

Table-5 : A comparison of the per palm productivity in the different districts of Kerala State

Name of district	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86
Trivandrum	38	NA	38	35	36	34	27	45	35
Quilon	30	,,	31	32	34	34	23	38	30
Pathanamthitta	—	,,	—	—	—	—	18	31	39
Alleppey	32	,,	34	31	29	29	26	40	40
Kottayam	26	,,	21	23	23	23	18	23	26
Idukki	30	,,	20	30	23	23	19	23	33
Ernakulam	32	,,	39	36	40	39	28	41	37
Trichur	43	,,	36	39	44	44	36	33	44
Palghat	30	,,	29	27	27	28	23	28	38
Malappuram	37	,,	35	33	30	29	20	29	29
Calicut	33	,,	34	32	29	29	33	39	33
Wynad	—	,,	—	—	19	13	10	12	22
Cannanore	25	,,	32	26	26	25	24	35	33
Kasaragod	—	,,	—	—	—	—	—	—	18

NA= Not available

practices in maintaining a satisfactory productivity level even in the presence of the root-wilt disease.

Going back to the differential productivity per hectare of coconut holding among the states of Kerala, Tamil Nadu and Karnataka, it is of practical significance to note the differences in the palm population per unit area in the three states. When the average density per hectare is 229 palms and Kerala, the corresponding figure for Tamil Nadu is 319 palms and for Karnataka only 122 palms. In all the states, the proportion of the bearing palms is more or less the same, that is, roughly two-third of the total population. This differential density is very much reflected on the productivity levels also. Despite the high average yield of 54 nuts per palm in Karnataka, the per hectare yield in the State is only 5178 nuts, which is not very much higher than that of Kerala. This is mainly due to the low palm population per unit area in Karnataka in comparison to other states. On the other hand, in Tamil Nadu, with a comparatively low per palm yield of 44 nuts, the per hectare productivity is nearly 9524 nuts which is very much higher than that of Karnataka. This is presumably due to the high palm population per unit area which shows that under proper management conditions, a high density may prove to be useful. In that case, it has a relevance to the conditions in Kerala, particularly in those districts where disease is the limiting factor for high productivity.

Though the present productivity of the crop in the major growing belts is not considered satisfactory, it has potential for further increase. Through a well planned effort for production increases by expansion of area in the potential states and for productivity increases in the traditional coconut belts, India could advance her position to the forefront among the coconut growing countries in the world. Production and productivity increases assume special significance to the country in the context of the present stagnation in production level which is likely to fall short of the projected demand of 9359 million nuts by the year 1989-90 by approximately 2739 million nuts unless the present production level achieves an increase of about 41 per cent.

Utilisation of coconut products

Of the varied products of coconut, only husk and copra are commercially exploited in India. Coir manufacture and copra crushing are traditional industries in the country. The manufacture of desiccated coconut and the commercial utilisation of shell are yet to be developed.

Coir and coir products

India, particularly Kerala, is the traditional home of coir industry. In Kerala, the industry has taken deep roots and is of considerable significance to the rural economy. The collection of husks, retting, fibre extraction, spinning of yarn and manufacture of mats and mattings provide direct employment to over 2.8 lakh people. There are about 2770 retting and 87,724 spinning units distributed over 260 villages in Kerala. The manufacturing sector comprises about 3,848 industrial establishments over 98.7 per cent of which are located in Alleppey district in Kerala. The special feature of the coir industry in the state is in the production of white fibre from retted husks and its subsequent use in the manufacture of yarn, door mats, mattings, rugs and cordages and rope. In no other part of the world, the production of white fibre and coir yarn has developed on a commercial scale. In Sri Lanka, the production is mainly of mechanically extracted brown fibre from unretted husks and of late, the production of limited quantities of machine spun yarn from brown fibre has been started. India has started the production of brown fibre also. While the production of white fibre is concentrated in Kerala where the extensive backwaters, streams and lagoons provide ideal facilities for natural retting, the brown fibre production is almost entirely confined to the states of Karnataka and Tamil Nadu.

India and Sri Lanka are the two major producers of coir & coir products in the world. The annual production of coir production in India is 164,000 tonnes which form about 55 per cent of the total world production. Sri Lanka follows closely with a contribution of about 28 per cent. India has virtually the monopoly in the production of white fibre and coir yarn. The world production of white fibre is estimated at 131,000 tonnes constituting about 52 per cent of the production of all kinds of coir fibre. The production in India is 124,800 tonnes (95 per cent) and in Sri Lanka, 6,200 tonnes. Over 90 per cent of the world production of white fibre is spun into yarn and the annual output is 126,000 tonnes. The production of yarn in India is 102,360 tonnes. Among the coconut producing countries, India produces finished products like mats, mattings, other floor coverings, etc. Recent reports indicate that countries like Philippines, Thailand and Sri Lanka have started production of finished products. The annual production in India is about 25,000 tonnes of mats, mattings and other floor coverings and about 18,370 tonnes of coir rope.

The internal demand for coir products is on the increase and absorbs about 35 per cent of the total output. The fact that India with only 17 per cent of the world coconut production accounts for 55 per cent of the coir production in the world is definitely an indication of the importance the industry has assumed in the country. But not more than 25 per cent of the total production of husk is currently utilised for processing, mainly for want of retting facilities in the areas or production. Even in Kerala, which accounts for over 90 per cent of the coir production in the country, only less than 35 per cent of the available husks are utilised for extraction. The situation is likely to change with further progress in the mechanical extraction of fibre. Another factor which thwarts the pace of modernisation of coir industry in the country is the inadequate technological development. In West European countries, a large variety of superior quality coir products such as creel mats, Japan mats, mattings and PVC based floor coverings are produced from the yarn imported from India. This has become possible because of technological advances and consequently, the developed countries could compete quality-wise with the products manufactured in India in the International markets. There is, therefore, an obvious need for the development and application of modern technology in the coir processing sector in India.

The Coir Board set up under the Ministry of Industry and Company Affairs, Government of India with headquarters at Cochin is the national agency responsible for the integrated development of the industry covering production, research and domestic and export trade. The Board was constituted on 9th February 1954 under the Coir Industry Act, 1953 of the Government of India and is composed of representatives of producers, processors, traders and exporters.

Copra

The processing of coconuts into milling copra is concentrated in Kerala State and to a lesser extent in the island groups of Lakshadweep, Andaman and Nicobar and also to some extent in the State of Tamil Nadu. The total production of milling copra is about 390,000 tonnes of which over 98 per cent is produced in Kerala. It is interesting to observe that India with a share of about 17 per cent of the total production of nuts in the world has a share of only 9 per cent of the total copra output. The Philippines with a share of 27 per cent of the nut output accounts for 39 per cent of the copra output in the world. The corresponding figures for Indonesia and Sri Lanka are 24 per cent and 5 percent against their respective contributions of 23 per cent and 8 per cent of the nut output. These differences clearly show the consumption pattern of coconuts in the respective countries for edible purposes. In India, only 40 per cent of the total production of nuts becomes available for further processing, the rest being utilised for edible purposes in the household sector. Apart from milling copra, a small quantity of edible copra is also produced in the country, mainly in the states of Karnataka and Andhra Pradesh. The total production is 50,000 tonnes a year and is mostly consumed in states where fresh nuts are either not readily available or difficult to get. Quality wise, the milling copra produced in India is only next to that of Western Samoa. The average extraction percentage of copra produced in the country is 62.5 against the corresponding figures of 65 in Western Samoa, 62 in Thailand and Philippines, 61 in Sri Lanka, 58 in Indonesia and 57 in Malaysia.

Though the production of milling copra is a traditional rural industry, it does not come under the organised sector but is in the hands of innumerable small processors spread over the main producing centres. In most cases, the processors are middle men who collect harvested nuts from the small producers for further processing and trading in copra. It is estimated that over 8000 small units are engaged in the manufacture of copra in Kerala State. In all the processing areas, brisk processing takes place in the summer months as sun-drying is the most popular method adopted throughout the country. In general, about 65 per cent of the supplies of milling copra arrive in the market during the first six months of the calendar year. During rainy weather, direct heating in smoke kilns is the usual method which is often combined with sun-drying. The use of mechanical driers for indirect heating has not yet become popular among the processors. In Kerala, oil fired or electrically operated hot air drier with a capacity to process 20,000 whole nuts in 24 hours has been introduced in the market. In this drier, either furnace oil or coconut shell is burnt under controlled conditions and the iron plates provided in the combustine chamber get heated. Electricity is also used to heat the iron plates. The air which is drawn in by an exhaust fan gets heated cn the other side of the iron plates and the hot air is blown through a tunnel into the drying chamber by means of a blow fan driven by electric motor. The hot air escapes through the perforations of the tunnel and passes through the copra layer arranged on extensive iron grill, installed about 1 to 1.5 metre above the tunnel. A thickness of about 0.5 metre is adopted for the layer of split nuts and a little more for the copra. For the initial drying, a temperature of 70°C is maintained continuously for eight to ten hours and by that time, the copra gets detached from the shells. After scooping, the copra is dried at 65°C, slowly reducing to a final range of 55°C to 60°C. The final drying takes about 14 to 15 hours, Trials have shown that the drier is useful for bulk processing and for the production of quality copra. However, since the copra processing is generally in the hands of small holders and middle men with limited resources and the price incentive for quality copra is not attractive enough, the preference will always be for sun-drying or for a combination of sundrying and kiln drying during uncertain weather. Even when the price incentive is attractive, the use of hot air drier is likely to become feasible only under the aegis of processors' co-operatives.

While 10 to 11 month old nuts are used for the production of milling copra and for coir processing, fully matured nuts are utilised for the production of edible copra. It is made both as cups and balls. Ball copra is of superfine quality and command a premium price in the markets. The processing also takes more time as the nuts will have to be stored under controlled temperature for about eight months allowing the nut water to be absorbed by the kernel completely. When the kernel gets detached from the shell, the nut is dehusked and kernel taken out in the ball form after deshelling. The cups are prepared by sun-drying, but careful selection of fully matured uniform sized nuts is necessary.

The copra processors sell the milling copra either to the nearby milling units or in the assembling markets. The major assembling markets for milling copra in Kerala are Alleppey, Calicut and Badagara. Bulk of the copra entering these markets are for upcountry sales. The copra is traded chiefly through commission agents of upcountry buyers. Invariably the upcountry buyers are millers from Maharashtra and West Bengal and consequently, no other intermediaries are involved in the transactions. About 52 per cent of the total production of 382,000 tonnes of milling copra in Kerala is utilised for crushing in the local milling sector and the balance 48 per cent is transacted in other states. The price of copra is more or less determined by the prevailing oil price. In general, a basic assumption of 62.5 kilo oil and 35 kilo cake from one quintal of copra is utilised by millers in fixing the price of copra. The edible copra is not consumed in the producing centres. It finds markets in other areas where coconut is not grown.

Coconut oil and cake

The milling industry is traditional to the country with a very slow pace of modernisation. Both rotaries and expellers are used for crushing and the average recovery of oil is 62.5 per cent in rotaries and 64 per cent in expellers. The total production of oil in the country is 246,000 tonnes, which is 12 per cent of the total production in the Asian region. The percentage contributions of other countries in Asia are 52 for Philippines, 28 for Indonesia, 5 for Sri Lanka and 3 for Malaysia.

There are 1,439 milling establishments in India composed of about 121 expeller units and 1,318 rotary units. In Kerala, where about 76 per cent of the milling units are located, there is a disproportionate concentration of rotary mills accounting for 77 per cent of the total rotaries in the country. Consequently, the milling sector in the State commands only 54 per cent of the total installed capacity in the country. On the other hand, Maharashtra with only 28 milling units commands about 29 per cent of the installed capacity (Table-6).

In Kerala, most of the expeller units are of recent origin and are not effectively working due to various reasons. Similarly, more than 30 per cent of the rotary units are now idle and in the case of others, the full installed capacity is not utilised. The expeller units alone have a total crushing capacity of about 138,000 tonnes of copra if worked in three shifts for 250 days in a year. If the existing milling capacity of expellers and rotaries in the State is fully utilised, the entire quantity of copra produced in the State could be crushed locally. However, only 200,000 tonnes of copra are crushed within the State with an annual output of about 126,000 tonnes of oil. Most of the small rotary units have only limited capacity and the production is usually adjusted to equate the demand

Table-6: The distribution of milling units

State	Expeller	Rotary	Total	Installed capacity/8 hours (Qts)		
				Expeller	Rotary	Total
Kerala	79	1,009	1,088	1,829	3,868	5,697
Maharashtra	25	3	28	3,098	10	3,108
Andhra Pradesh	1	129	130	6	349	355
Karnataka	2	105	107	21	390	411
Tamil Nadu	3	70	73	13	401	414
West Bengal	11	—	11	556	—	556
Gujarat	—	2	2	—	4	4
Total	121	1,318	1,439	5,523	5,022	10,545

from the consumers and the retailers of the locality. The bigger milling establishments find outlets in the major oil markets in the State. The important oil markets in Kerala are Cochin and Calicut. In the assembling markets, the oil transacted is mainly for upcountry markets. Here also the trading is through brokers or commission agents. Occasionally, organised end users also enter the markets but this is not a regular feature. Similarly, a few of the bigger rotary and expeller establishments do not operate in the local assembling markets but have their own marketing arrangements in the upcountry centres. It is estimated that nearly 46,000 tonnes of oil are marketed from Kerala annually and the balance utilised for consumption within the State.

Nearly 182,000 tonnes of milling copra move out of Kerala State for crushing in other states. The crushing units in these states also utilise the milling copra produced locally. The combined output of oil from all these centres is estimated at a little over 120,000 tonnes. Thus the total availability of coconut oil for various end uses outside Kerala ranges from 1,65,000 to1,70,000 tonnes. In addition to the above about 3,000 tonnes of solvent extracted coconut oil is also available in the country. The important outside markets are Madras, Bombay and Calcutta. From these centres, the oil is ultimately traded through a large number of wholesale and retail cutlets even to the remote villages in the respective states.

The bulk of the oil cake produced in the country is utilised for feeding cattle. leaving only a small percentage for further processing in the solvent extraction plants. There are about a dozen solvent extraction plants in the country. The cake prices are slightly more than that of compound feeds, but a large section of cattle growers still prefer the cake for direct feeding. Almost the entire quantity of cake produced in het country is consumed for this purpose and the demand matches the supply. Because of the high unit value of the coconut protein, compound feed manufacturers do not prefer solvent extracted meal as their raw material. Nor is it preferred by cattle growers for direct feeding. Thus the meal is confronted with a marketing problem which is the main reason for not utilising the entire quantity of cake for further processing.

Desiccated coconut

The desiccated coconut industry is slowly developing in the country. The domestic demand for dessiccated coconut is mainly from bulk consumers and is fully met by the present production which is around 10,000 tonnes per annum. This is definitely insignificant when compared with the production levels in thePhilippines and Sri Lanka which are 92,000 tonnes and 33,000 tonnes respectively. Compared to the international prices, the domestic prices of the product are very high. The demand for the product in the domestic market is confined to a small number of organised confectionary units. However. there is scope for developing a market for the product in those states where coconut is not grown but is in demand for household uses.

Coconut protein and other food products

Fresh coconut kernel contains about 4 to 4.5 percent protein. When the coconut is processed into copra and oil in the traditional way, the major portion of the original protein passes on to the coconut meal which is the residual product after oil extraction. This meal will have a protein content of about 18 to 25 percent and a high fibre composition. The meal.

however, is not considered suitable as a protein supplement, because in the process of oil extraction the original protein gets discoloured and denatured due to the generation of a very high temperature. In view of this disadvantage and also of the high fibre content of the meal, it is generally used in ruminant feeding.

Extraction of edible quality protein, oil and flour from the fresh kernel has been proved to be technically feasible in the country. The modified Krauss-Maffei process developed by the Central Food Technological Research Institute, Mysore though technically feasible, is still to be pilot-tested for determining its commercial feasibility. A recent development in the field is the 'Modified Solvol Process' which was developed and pilot tested by the Chemical Construction Company Private Ltd., in their unit at Faridabad near Delhi. This process, though fundamentally the same as the KM/CFTRI Process, Texas A & M University Process and the T. P. I. Process, combines solvent extraction at different stages for ensuring maximum recovery of oil. The reported recovery of various products is 38.3 per cent oil, 10.12 per cent protein-sugar mixture and 5.81 per cent coconut flour based on weight of fresh kernel. But commercial application of the technology so developed has not been successfully ventured in the country.

In the Philippines, coconut water is utilised for the preparation of varied food products such as 'Nata De Coco' and vinegar. In India, the entire nut water is wasted. The high cost of sugar is a limiting factor in the preparation of sweet products from coconut water as developed in the Philippines, Yet, there is good scope for effectively using coconut water in the manufacture of vinegar by cheaper methods as done in Sri Lanka. The vinegar prepared out of coconut water could compete with synthetic vinegar.

The Regional Research Laboratory (CSIR), Trivandrum has perfected a process for the preparation of soft drink from matured coconut water. Perfection of technology for preservation of coconut cream is also progressing in that laboratory.

Shell products

Only a small portion of the total shell output in the country is currently used for conversion into flour and also into charcoal. The use of shell charcoal for activation is slowly developing in the country. Some shell flour units have come up in Karnataka, Tamil Nadu and Kerala where shell is available from the desiccated coconut units at cheaper rate. The technology for preparing shell flour of 300 mesh size or above which alone is in demand in the organised industries has not been commercially developed. There is immense scope in this field.

The consumption pattern of coconut products

Coconuts are used both as tender nuts for drinking purposes and as mature nuts for religious and household culinary purposes. In Kerala, more than 30 per cent of the total production is consumed as mature nuts for edible uses. In other states, except the Island groups, 75 per cent of the production is consumed either as tender nuts or as mature nuts for various household purposes, Thus, 55 to 60 per cent of the total production in the country is consumed as fresh nuts. The rest alone is converted into edible copra, desiccated coconut and milling copra.

Coconut oil is used both for edible and non-edible purposes. The household edible uses of coconut oil are restricted to Kerala State. The studies undertaken in this regard have shown that the total consumption of oil within the State is about 80,000 tonnes. The estimates indicated a consumption of 68,000 tonnes in the households and other establishments for edible purposes. The non-edible toiletry uses in the households in Kerala may be around 12,000 tonnes.

In the rest of the country, the total availability of oil for various end uses is around 165,000 to 170,000 tonnes. Unlike in Kerala, coconut oil is not used for edible purposes in the households in other states except in pockets where sizeable Malayalee populations are concentrated. in the organised food industry, especially in vanaspati the uses of coconut oil is practically nil, with only insignificant quantity being used in bakery and confectionary units. In the edible sector, the demand for coconut oil is influenced by groundnut, sesame and mustard oils. Besides, fair quantities of other oils such as sunflower oil, soyabean oil, cotton seed oil, etc. are also used for edible purposes.Over 90 percent of the supplies of groundnut oil, sesame oil and mustard oil are used in the edible sector in one form or other. Bulk of the supplies of other oils are also utilised for edible purposes. Though many oils are used for edible purposes in the households the influence of one or a group of oils on the demand pattern of other oils is not significant. This is mainly because of the characteristic qualities of each oil and the differential food habits of the population. While coconut oil could maintain the demand in the households, it has lost a considerable portion of the markets in the edible industrial sector, consequent on the substitution facilitated by the easy availability of other oils and fats at comparatively cheaper prices. Taking the country as a whole, the consumption of coconut oil in edible end uses is likely to be 100,000 tonnes or 40 per cent of the total output.

In the non-edible sector, soap industry is the only organised area where coconut oil finds bulk use. Even there, the use is very much restricted in the organised sector and intake of any significance is visible only in the unorganised soap units. Once coconut oil was considered indispensable and price inelastic in some of the non edible end uses. Coconut oil was also regarded as invulnerable to substitution at least in soap industry. However, technological developments have made it possible to displace coconut oil by other oils and fats. During the last decade, the use of coconut oil in soap industry has recorded a steep decline from 25-30 per cent to around two per cent. The official estimate of the current consumption of coconut oil in soap manufacture is 20,000 tonnes only against the annual output of about 10,00,000 tonnes of toilet and laundry soaps. However, sizeable quantity of the oil may be in use in the unregistered units. Similarly, the organised toiletry and perfumery units also do not use coconut oil in sizeable quantities. But in households, even in states where coconut oil is not produced, the oil finds reasonable demand for toiletry uses. A critical study of the demand behaviour of coconut oil shows that the oil can find use in areas where other oils and fats are currently in use or in areas where the use of coconut oil has been stopped owing to economic considerations, when the coconut oil prices fall to levels comparable with that of other major oils and fats, say for example, groundnut oil. This is important because when the prices rule low, coconut oil can command an increased end use demand especially in the non-edible industrial sector where the prime consideratation is comparative cheapness or other-wise of a particular oil. The unique chemical and other characteristics of coconut oil also give an edge to this oil over other oils and fats even at a slightly higher price margin in certain end uses particularly in soap industry. As it is, the estimated consumption of coconut oil in all the non-edible end uses in the country is about 150,000 tonnes or 60 per cent of the total supplies of oil.

In short, coconut oil is considered indispensable and price inelastic for edible and toiletry uses in the household sector and for soap manufacture in the small scale soap units in the rural areas. The normal price fluctuations do not influence the toiletry demand because slight changes in the expenditure on this small items do not disturb the household budget. In the organised industrial sector, the demand is considered elastic and the use of coconut oil depends very much on the price factor. If the price is very favourable in relation to that of other major oils and fats, coconut oil can become a substitute for other oils and fats. Recent studies have shown that about 190.000 tonnes of coconut oil fall within the range of inelastic demand and the demand for the balance around 55 000 tonnes of oil is influenced by price.

Supply Fluctuations of Coconut Oil

The estimated availability of coconut oil based on the production figures of coconut for four years is given is Table-7.

The production of coconut oil has been showing an increasing trend since 1981-82. Though the production of coconut oil is only 16 per cent of the snpplies of groundnut oil in the country, in certain end uses coconut oil is preferred because of its intrinsic qualities. In the absence of adequate supplies of other oils and fats in the country, coconut oil is likely to enjoy an expanded market demand even at a wider price premium.

Price behaviour of Coconut Oil

In India, the demand for coconut oil is steady over short periods and the prices also maintain the general trend. International prices do not influence the domestic prices. Unusual behaviour in certain years is more related to the changes in the overall supply position of oils and fats in the country than to any other single factor. Whenever there is any significant deficit in the overall supply position of oils and fats in the country, the coconut oil price is the first to react benefiting the coconut growers. Normally, coconut oil prices

Table-7 : Estimated availability of coconut oil in India

Year	Coconut oil in tonnes*		
	Production	Imports	Total
1981-82	221,673	45,527	267,200
1982-83	236,360	7,304	243,664
1983-84	215,827	3,262	219,089
1984-85	256,924	9,085	266,009
1985-86	246,005	NA	246,005

* Export in terms of copra or coconut oil during the years is quite negligible, i.e. less than 500 tonnes.

command a premium over other oils and fats and are not infuenced by the availability and price behaviour of any individual oil in the country.

Very often, coconut oil prices exhibit unpredictable daily fluctuations causing concern to the producers, processors, traders and end users. Further, the variations in the prices observed within a month do not maintain any uniform pattern over different months. It may be as low as one per cent in some months and as high as 24 per cent in some other months. This uncertainty in the price development always breeds an element of risk for all categories of processors, for copra manufacture takes 6 to 7 days under normal conditions and copra crushing 3 to 4 days.

As already stated, only about 46,000 tonnes of coconut oil move out of Kerala for use in other states. But in other states, especially in Maharastra where the milling copra obtained from Kerala is crushed, substantial quantity of oil becomes available over which the oil markets in Kerala have no control. Consequently, there is always a price difference between the Cochin and Bombay quotations. The prices are invariably high at Bombay and for different years, the price premium was found to vary from 5 to 10 per cent over that quoted at Cochin. This price premium can place the millers and traders in Maharashtra at a very advantageous position compared to their counterparts in Kerala even after covering the additional expenses like tax differences, commission, transporting and other incidental expenses. Naturally, the oil prices at Cochin and other centres in Kerala are determined by the Bombay quotations and the demand from upcountry centres.

The annual average prices quoted per quintal of coconut oil at Cochin and Bombay and of groundnut oil at Bombay for the last 11 years are presented in Table-8.

It could be observed that the prices of both the commodities were on the

Table-8: Average aunual prices of coconut and groundnut oil (price in rupees per quintal)

Year	Cochin	Bombay		
	Coconut oil	Coconut oil	Groundnut oil	Difference
1976-77	1,029	1,195	NA	—
1977-78	1,058	1,111	821	290
1978-79	1,162	1,234	691	543
1979-80	1,211	NA	839	—
1980-81	1,572	1,656	1,073	583
1981-82	1,306	1,406	1,402	4
1982-83	1,558	1,716	1,381	335
1983-84	2,396	2,535	1,591	944
1984-85	3,242	3,415	1,634	1,781
1985-86	1,701	1,873	1,528	345
1986-87	2,433	2,564	2,080	484

NA=Not available.

increase over the period studied. Further, the year to year fluctuations in coconut oil prices are more pronounced indicating the sensitiveness of coconut oil prices in relation to even slight changes in demand or supply position. This is quite evident from the fact that shifts in the price level of coconut oil during the periods 1982-83 to 1983-84, 1983-84 to 1984-85 and 1984-85 to 1985-86 have been quite abnormal. Price level exhibited a sudden boom through the period 1983-84 to 1984-85, reaching the maximum level of Rs. 3,415 per quintal in 1984-85 (Bombay). The reason for this unprecedented increase in price level could be traced to the slump in production of coconut in Kerala as a result of severe drought in two consecutive seasons in 1983-84 and the shortfall in production of other major vegetable oils. But 1985-86 witnessed a sudden crash in the price level of coconut oil from from Rs. 3,415 to Rs. 1,873. Recovery of production of coconuts in 1985-86 resulting in increased arrivals of the commodity and the improvement in the overall availability of vegetable oils consequent on imports have pushed down the price to abnormally lower level. However, in 1986-87 price level showed significant improvement. During 1987-88 season, even though coconut oil prices ruled at higher levels compared to the previous year, the price level remained almost stable which is a healthy sign. Groundnut oil prices are devoid of such violent fluctuations as in the case of coconut oil. In all the years, it could be seen that coconut oil prices always commanded a premium over groundnut oil prices, the premium sometimes going up to Rs. 1,781 per quintal. No definite pattern of the premium could be observed from the range of price premium. It could be seen that whenever a boom in coconut oil prices occurs, the price difference also attains an abnormal level.

The important features in the price behaviour of coconut oil relative to that of other oils and fats in the country can be summed up as follows:

Coconut oil prices exhibit wide fluctuations which are manifest in the daily, monthly and yearly price levels.

Coconut oil has consistently commanded a price premium over other oils and fats especially groundnut oil. The usual premium commanded by coconut oil over groundnut oil varied between Rs. 290 and Rs. 1,781 per quintal during the periods 1976-77 to 1986-87 except for the year 1981-82 when the difference was minimum at Rs. 4 per quintal.

The annual and seasonal price behaviour of coconut oil in normal years is in harmony with the supply position (market arrivals) and abnormal behaviour was noticed during the period 1983-84 to 1986-87.

Consequent on the inelastic demand enjoyed by coconut oil for the household uses, supply variation could be an important cause for price fluctuations. The influence of traders on the price behaviour is also important. The exclusion of coconut oil from the list of oils permitted for use in vanaspathi and the restrictions in the sale of solvent extracted oil have also weakened the competition by contracting the market demand. The high price premium and the erratic price behaviour have promoted both economic and technical substitutions in many organised end uses where coconut oil was once in demand. Consequently, coconut oil has lost its pre-eminenne and the specific end use demand it enjoyed, with the result that it is now one of the many oils and fats which are exchangeable at will for different purposes in the industrial sector. The interrelationship between the price behaviour and the demand for coconut oil in the industrial sector could be summed up as follows:

> Price is the major factor affecting the demand for coconut cil.
>
> Owing to the uncertainty reflecting both on the supplies and prices, coconut oil is not considered dependable by the organised end users.
>
> Though vulnerable to substitution, the special qualities of coconut oil enable it to enjoy a preferential treatment, where product quality is important.
>
> By minimising the p'ice fluctuations and ensuring stability in the supplies at prices not very much higher than those of other oils and fats, particularly groundnut oil, the present demand could be improved substantially.

Export trade in Coconut Products

Export trade of India in coconut products is practically restricted to coir products and its share in the world market is 23 per cent. Sri Lanka controls 72 per cent of the world coir export. The exports from India are coir yarn (50 per cent) followed by mat and mattings (48 per cent) (Table-9).

In other commodities, India has no regular export trade except of course in oil cake which is also on the decline mainly because of the unfavourable shipping cost and low international price for the product. When import of copra was allowed, export of the resultant cake was made compulsory. The low returns from the export trade in cake were compensated by allotting imported copra to various users at a price much below the domestic price. The world export trade in copra meal is now almost equally shared by Indonesia and Philippines. In the coconut oil export trade, Philippines has the monopoly position controlling 60 per cent. Similarly, desiccated coconut export is controlled by Sri Lanka and Philippines. From India, a small quantity of coconuts is exported to the Middle East and some copra and oil to Bangladesh and Nepal as part of trade agreement. The figures of

Table-9: Export of coir and coir goods.

Year	Quantity in tonnes	Value in million rupees
1976-77	44,357	227.8
1977-78	42,444	239.2
1978-79	43,066	257.9
1979-80	47,225	372.1
1980-81	28,610	255.5
1981-82	30,079	269.4
1982-83	30,133	261.7
1983-84	27,949	243.4
1984-85	25,788	264.1
1985-86	24,672	328.5
1986-87	23,214	314.4

export of cake, coconut, copra and oil for the last 10 years are given in Table-10.

The factors determining the export quantum of any commodity is its abundance and the international price, relative to the domestic prices. India and Indonesia are comparatively larger countries and their domestic demand for oils and fats is more than the supplies. The tendency, therefore, is to consume the entire production within the country itself. The internal prices of coconut products in India are more than double the international prices (Table-11).

On the other hand, the internal prices in the major exporting country such as the Philippines are less than the international prices and they stand to gain by exports. Consequent to these, the export trade of India in coconut products is confined to coir and coir products.

Table-10: Export of coconut and coconut products from India

Year	Coconut cake (Qty. in tonnes)	Coconut (in '000)	Copra (in tonnes)	Oil (in tonnes)
1975-76	4,365	174	69	81
1976-77	4,686	293	292	6
1977-78	2,810	812	278	1
1978-79	5,157	89	576	12
1979-80	9,660	159	458	3
1980-81	1,057	88	705	Negligible
1981-82	2,648	114	438	1
1982-83	2,030	201	240	Nil
1983-84	1,549	150	Nil	Nil
1984-85	755	102	1	7

Table-11: Prices of coconut products (in Indian rupees) in the major producing countries as on 10-9-1987.

Country	Copra/tonne	Coconut oil/tonne
India	22,500	33,500
Indonesia	3,701	5,733
Philippines	5,524	5,977
Sri Lanka	NA	7,273
International price		
Philippine copra CIF Europe		4,138
Philippine coconut oil CIF New York		6,556

RESEARCH AND DEVELOPMENT

Coconut Research

Coconut Research in India has a history of over 70 years. While published papers on the pests and diseases of coconut palm appeared during the first decade of the present century, scientific study on the major disciplines of the palm commenced only in 1916. It was in that year that the Government of the then Madras Presidency established three coconut research stations at Nileshwar and one at Kasaragod which are now located in the Cannanore and Kasaragod districts respectively in Kerala State. In all these stations, research was oriented to the study of the genetics of the palm and the agronomic and cultural requirements in relation to the soil and climate. The research activities gained further momentum since 1945 with the establishment of the Indian Central Coconut Committee under the Indian Coconut Committee Act of 1944. The Committee, which was a statutory body, took over the research under the disciplines of botany, agronomy, cytogenetics and analytical chemistry. In 1948, another research station was set up at Kayamkulam in the erst-while Travancore State to intensify research on the pests and diseases of the palm, particularly on the root (wilt) disease. The Committee in the subsequent years encouraged and financed the establishment of nine regional coconut research stations in the different coconut growing states for taking up scientific studies in relation to the local agro-climatic situations. The research activities in the two central coconut research stations at Kasaragod and Kayamkulam and in the nine regional research stations located in the different states continued under the unified control of the Committee till March 1966. Consequent on a policy decision of the Government of India, the Indian Central Coconut Committee was abolished in 1966 and coconut research was brought into the mainstream of agricultural research in the country under the Indian Council of Agricultural Research (ICAR).

With the abolition of the Committee, the regional research stations remained with the agricultural departments of the respective states and the Central Coconut Research Stations at Kasaragod and Kayamkulam became the main centres for coconut research in the country under the technical and administrative control of the Indian Council of Agricultural Research. In 1970, the Central Plantation Crops Research Institute (CPCRI) was established by the Indian Council of Agricultural Research with headquarters at Kasaragod by strengthening the Central Coconut Research Station. The other station at Kayamkulam was also strengthened and made the Regional Station of the CPCRI. In order to strengthen and co-ordinate the research on coconut in the country, the ICAR sanctioned in 1971 an all India co-ordinated project for the improvement of the crop with Kasaragod as the headquarters. Co-ordinated research in different disciplines has been taken up under this project in 13 co-ordinating centres located in 9 states, most of the centres being the old regional research stations now attached with the agricultural universities.

Though the CPCRI is the national organisation for coconut research in India, the role of the Kerala Agricultural University is equally important so far as coconut research in Kerala State is concerned. Coconut being the major crop of Kerala and of vital importance to the economy of the State, the Agricultural University is giving special emphasis to coconut research. particularly on problems relating to varietal improvement, mineral nutrition, productivity increase and to the control of root(wilt) disease. Two of the oldest three research stations which were set up at Nileshwar in 1916 and the two research stations located at Balaramapuram in Trivandrum district and at Kumarakom in Kottayam district which were originally the regional research stations established with the financial assistance of the erstwhile Indian Central Coconut Committee, are now under the Kerala Agricultural University, where coconut research is intensified to solve the varied problems,

During the past 70 years, the studies conducted in the different research centres on the fundamental and applied aspects of the palm have produced valuable results of practical significance. The information yielded by research has been instrumental in shaping a systematic approach to the problems of coconut production in the country. The field application of valid research findings has always been the basic philosophy of coconut development in the country. In the process, the research is also fed back with problems wherever breaches are identified in the present day knowledge on basic issues. Neverthless, the two-way flow is not always complete because many useful research indications are often left unutilised or not absorbed in the strategy of coconut development.

Coconut Development

Though the coconut palm has been known to exist in India since 3000 years ago, organised efforts to develop the crop were begun only about a century ago. The history of its development and the commercial exploitation of the products has three distinct phases covering the latter half of the last century, the period from 1900 to 1945 and from 1945 to 1976.

The First Phase

The first phase of coconut development coincided with the expansion of European soap and edible oil industry which required large quantities of imported copra for feeding the milling sector. The increased demand for coconut products in the European markets gave a fillip to coconut cultivation and copra trade. With the introducticn of wheeled traffic and increased shipping facilities, the export trade in coconut products expanded considerably which resulted in a renewed interest in coconut cultivation and focussed attention on the urgency of taking up the cultivation and development of coconut in an organised manner.

The intensive cultivation of coconut which started consequent on the above developments was also not free from problems. It was sometime during this period that the coconut growers in the then central Travancore area of Kerala State noticed the incidence of an unknown disease in isolated patches which is now known as the root (wilt) disease of coconut. In 1897, the coconut growers of the area presented a memorandum to the Government describing the financial loss suffered by them due to the incidence of this disease. Roughly about the same time the coconut growers on the East Coast (Godavari District in Andhra Pradesh) were also in distress caused by the high incidence of bud-rot disease. The British, as could be expected of them would have looked the other way had not their trade interest also been involved and they were compelled to appoint Dr. E. J. Butler, the Imperial Mycologist to investigate the problem. Though Dr. Butler could not identify the etiology of the root(wilt) disease nor could suggest measures for alleviating the sufferings of the growers, his recommendations helped to develop a modern line of approach to the problems of coconut cultivation in the country. Towards the end of the last century, agricultural departments were established in various states, thereby making coconut development a recognised item of work.

The Second Phase

The dawn of the present century found India in a formidable position in the export trade in copra and coconut oil. During the years 1909 to 1914, India exported about 31,000 tonnes of copra and 9000 tonnes of coconut oil annually. The increase in demand and the favourable price level maintained the tempo on the production front which unfortunately, did not last long. The prices started crashing during the first World War and the general economic crisis forced the growers to neglect the cultivation. Even after the war, the prices failed to recover and the apathy of the growers continued. During the post-war period, exports of copra and coconut oil started receding while imports gained momentum. By 1924, the exports had come to a standstill. Liberal imports of caustic soda into the country during the twenties had helped many soap units to come into existence. The development of soap industry, combined with increased domestic consumption of coconut and coconut oil finally caused a deficit in the commodity, a situation which continued to prevail subsequently.

Though export trade in coconut products ceased to continue, the domestic demand started to pick up which in turn necessitated governmental efforts for increasing the production. In 1916, with the establishment of the Coconut Research Stations at Nileshwar and Kasaragod, coconut development activities attained a purposeful momentum. At about the same time coconut farms started by the departments of agriculture in the then Cochin and Travancore regions of Kerala State also came into being. The agricultural departments disseminated among growers useful information gathered from these research stations and elsewhere. By the early thirties Government had come to recognise the importance of the genetic improvement of the crop and envisaged schemes for the establishement of coconut nurseries. During this period, the coconut area in the couutry also recorded a slight increase from 0.5 million hectares in 1920 - 21 to 0.57 million hectares in 1930 - 31.

The world trade in copra, coconut oil and other coconut products was seriously distrubed by the outbreak of the second World War. Though not an exporting country, the war situation in general had an adverse effect on the production and marketing of coconuts in the domestic sector also. The result was a dampening of spirit on all fronts. Decline in production coupled with marketing bottlenecks finally forced the Gevernment of India to initiate an enquiry in 1943 on the production aspects, regulation of imports of copra and coconut oil, improvement of quality of copra and better utilisation of shell and fibre. The Enquiry Commission recommended the setting up of a statutory body for coconut with powers and functions similar to those of the Ceylon Coconut Board. The Government of India accepted the recommendation to set up a statutory body with somewhat narrower functions than proposed. Thus, the Indian Central Coconut Committee was formed in February 1945 by virtue of the Indian Coconut Committee Act of 1944. The Committee continued to function till March 1966 and after that the Directorate of Coconut Development was established in its place, which took over the development and marketing of coconut in the country.

The Third Phase

The third phase which covers the period from 1945 to 1986 has heralded the era of coconut development in the country. It was during this period integrated efforts for modernising coconut cultivation and industry were promoted. Some of the major development programmes implemented during this period were the collection of reliable statistics on area and production, the establishment of Central and Regional Research Stations, the commercial production of coconut hybrids and the establishment of hybrid seed gardens, the coverage of more than 10 per cent of the total coconut area in the country under the package programme, the establishment of nurseries and parasite breeding stations, the financial assistance given to growers for expansion of area under coconut and the encouragement given to growers' co-operatives for improved marketing and processing activities. These promotional activities have led to a conspicuous increase in the area and production of coconut in the country (Table-12).

The Institutional Arrangements for Coconut Development

The Indian Central Coconut Committee which was established in the year 1945 was vested with statutory power for the overall development of coconut industry including research. In 1966, the Committee was abolished and in its place, the Directorate of Coconut Development with headquarters at Cochin was constituted under the Ministry of Agriculture, Department of Agriculture and Cooperation, Goverment of India. The Directorate was vested with the functions of planning and co-ordination of programmes relating to development, processing and marketing of coconuts in the country. The Directorate in association with the coconut growing states was involved in the integrated development of coconut industry in India. An advisory body, The Indian Coconut Development Council, representing various interests, both official, and non-official, connected with coconut cultivation, trade and industry was also constituted in 1966. The functions delegated to the Council were to review the coconut situation in the country and recommend measures to accelerate the tempo of development. The Council was composed of

Table-12: Changes in the area and production of coconut

Year	Area in '000 ha	Increase percentage	Yearly average	Production in million nuts	Increase (percentage)	Yearly average
1949-50	629.2	—	—	3251.3	—	—
1959-60	728.4	15.77	1.57	4845.5	49.03	4.90
1969-70	1033.3	41.86	4.18	5858.7	20.91	2.09
1974-75	1116.3	8.03	1.61	6029.6	29.17	5.83
1979-80	1075.8	-3.63	-0.73	5662.0	-6.10	-1.22
1984-85	1183.3	9.99	2.00	6912.8	22.09	4.42
Change in 35 years		88.06	2.52	—	112.62	3.22

(-) denotes negative growth

members of Parliament, progressive growers, representatives of trace and industry and officials of the state and central governments.

The Directorate of Coconut Development was subsequently abclished and in its place, the Coconut Development Board was established in the year 1981 under the Coconut Development Board Act 1979, enacted by the Parliament. The functions of the Board are the following :

- Adopting measures for the development of coconut industry,
- Recommending measures for improving marketing of coconut and its products,
- Imparting technical advice to those engaged in coconut cultivation and industry,
- Providing financial and other assistance for expansion of area under coconut,
- Encouraging adoption of modern technologies for processing of coconut and its products,
- Adopting measures to get incentive prices for coconut and its products,
- Recommending measures for regulating imports and exports of coconut and its products,
- Fixing grades, specifications and standards for coconut and its products,
- Financing suitable schemes to increase the production of coconut and to improve the quality and yield of coconut,
- Assisting, encouraging, promoting or financing agricultural, technological, industrial or economic research on coconut and its products,
- Collecting statistics on coconut and its products and publication of such data,
- Undertaking publicity activities and and publishing books and periodicals on coconut and its products. ☐

STATUS REPORT ON COCONUT RESEARCH, DEVELOPMENT AND BY-PRODUCT UTILISATION IN MALAYSIA

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In Malaysia, coconut cultivation has long been a business of low returns and has, therefore, not received as much attention as other plantation crops such as oil palm, rubber and now cocoa. A substantial section of the rural population, however, are dependent on coconuts for food and income. The government is showing greater attention in increasing the living standards of these local farmers. Planned intercropping and the introduction of the high-yielding hybrid coconuts have injected some life into the coconut industry. Compaigns have been launched to popularise the use of coconuts and its products.

STATUS OF THE INDUSTRY

In terms of area, coconut in Malaysia is an important crop with an area of about 334,000 hectares (Table 1). It ranks fourth after rubber, oil palm and paddy. However, it occupies only 8% of the total cultivated land under the main crops in 1985. The coconut industry has a net export value of $136.3 million with copra and crude coconut oil accounting for 97% of it (Table 2). In 1980, the net export value of this industry only accounted for 2% of the total net export of major crops (Sonarno, 1982) compared to 60% and 33% for rubber and oil palm, respectively.

Table 1. Agricultural land use pattern in Malaysia (1980, 1982, 1985)

Crop	Area planted ('000 hectares)			
	1980	1982	1984	1985
Rubber	2,000	2,006	1,967	1,947
Oil Palm	1,004	1,186	1,330	1,431
Paddy	600	682	632	656
Coconut	354	363	342	334
Cocoa	124	209	265	300
Miscellaneous	204	212	204	214
Total	4,286	4,658	4,740	4,882

Source : Department of Statistics, Malaysia and Ministry of Agriculture, Malaysia

Table 2: Import and export of coconut in Malaysia (1980, 1985)

Item	Import				Export			
	1980		1985		1980		1985	
	Quantity	Value ($' 000)	Quantity	Value ($ '000)	Quantity	Value ($ '000)	Quantity	Value ($ '000)
Copra (t)	26,742	18,766.9	39,240	24,723.5	43,289	34,745.6	61,848	44,004.4
Coconut fresh	(100) 7,671	18.0	903	26.4	247,009	5,576.3	352,385	10,506.7
Coconut desiccated (kg)	22,937	71.7	15	71.1	1,741,311	5,064.1	8,103	17,408.6
Coconut oil refined for domestic use (mt)	719	1,092.2	286	475.4	15,616	25,460.3	1,408	2,715.0
Coconut oil refined for other uses (mt)	167	216.5	35	93.1	1,305	2,907.0	44	94.0
Coconut oil crude (mt)	17	6.9	95	107.7	45,555	71,691.9	58,608	88,249.7
Oil cake and other residue of coconut (copra) (mt)	8,611	2,340.1	4,938	1160.9	157	32.8	—	—
Total		22,502.3		26,658.1		145,478.0		162,976.4

Source: Import and Export Trade in Food and Agricultural Products, 1980 and 1985, Department of Statistics, Malaysia.

Table 3 : Coconut area under estate and small holdings in Malaysia (1974, 1984 and 1985)

Year	1974			1984			1985		
Region	Estate	Small Holdings	Total	Estate	Small holdings	Total	Estate	Small holdings	Total
Peninsular Malaysia	17,965	199,818	217,783	23,433	202,700	226,133	24,381	195,600	219,981
Sabah	—	53,000	53,000	4,107	54,600	58,707	4,203	52,800	57,003
Sarawak	—	49,000	49,000	—	56,800	56,800	—	57,100	57,100
Total	17,965	301,818	319,783	27,540	314,100	341,640	28,584	305,500	334,084

Source : Department of Statistics, Malaysia and Ministry of Agriculture, Malaysia

Coconut production in Malaysia is primarily a small holder activity which in 1985 accounted for 91 per cent of the total area under coconut cultivation (Table 3). Approximately 90,000 to 100,000 households are dependent on the crop for a living compared to about 4,000 workers in the estate sector in 1983 in Peninsular Malaysia (Table 4). Small holder yields of copra range between 0.4 and 1.0 metric ton,/hectare/year while yield for estate ranges from 1.8 to 2.7 metric ton, the average being 0.9 and 2 metric ton/ha/year, respectively. From the above, it can be seen that the social implications of this industry far outweigh the economic importance, Many small holders are involved in the production of coconut products which have low economic and export values.

Table 4: Employment by crops in Estates in Peninsular Malaysia (1983)

Crop	Workers
Rubber	135,440
Oil Palm	92,810
Cocoa	6,500
Coconut	4,085
Tea	1,886

Source: Research and Planning Division. Ministry of Labour, Malaysia

Coconuts are grown all over Malaysia but are mainly planted on the marine clay and organic clay soils (Inceptisols) in the west Coast and marine alluvial sands (Entisols) and soils derived from riverine alluvium (Inceptisols) in the East coast (Chan, 1978). In Sabah, it is grown on the coastal soils around Kudat, Sandakan, Lahad Datu and Tawau. In Sarawak, the coastal plains around Mukah, Bintulu and Lingga are major coconut areas. However, coconuts, especially the hybrids, are being introduced to inland areas where cocoa are grown.

The problems faced by the industry are low productivity, poor prices and opportunity costs. It is unable to compete with the other plantation crops like rubber and oil palm. These crops are very well established and backed by intensive research and ample budget, whereas coconut is almost a neglected crop mainly grown by the small holders who are traditionally low-input producers. The suitability of the coastal clay soils for oil palm and cocoa coupled with their greater profitability have encroached on the traditional coconut areas. This has resulted in shrinkage of coconut area, especially in the estate sector as well as in the small holdings.

A high proportion of the plantings in the small holder sector are old local varieties which do not have the potential for high yields. Although high yielding hybrid materials are now easily available, the coconut farmers have been slow to take advantage of this. Apart from improved planting materials, cultural and agronomic practices must also be improved before the high yield potential of the hybrids can be realised. The profitability of coconut cultivation could be further improved by intercropping.

The viability of the whole coconut industry could be improved through greater exploitation of end uses such as the manufacture of desiccated coconuts, edible copra and coconut milk products. The by-products that are traditionally discarded could be put to greater use: for example, coconut shell for activated carbon and charcoal, coconut husk for coir fibre, coconut water for food and canned drink production and lastly coconut trunk for wood/boards.

RESEARCH AND DEVELOPMENT

Although coconut has been planted for a considerable length of time and over on extensive area in Malaysia until re-centy the quantum of research activity is meagre. A review of coccnut research indicated sparse information on coconut selection and breeding, results of few fertiliser trials on tall palms cn coastal soils and occasional reports of rare outbreaks of pests and diseases of coconuts,

Unless the profitability of coconut can be increased to levels that are competitive with the profitable alternative tree crops like oil palm and rubber, the industry is expected to decline and research/development programmes will be pocrly funded. At current levels of technology and prices, coconut farming can only be viable under an intercropping system and the best crop for this is cocoa.

Presently, coconut research in Malaysia is being conducted by MARDI and a a few research units in the private sector. In MARDI a multidisciplinary approach is adopted to carry out research and development to ensure the survival of the coconut industry. The key areas in which attention is being focussed are the following :

Increasing yield	: Breeding and Selection Nutrition and Agronomy Others
Intercropping	: Increasing profitability/ unit area
Post harvest technology & processing	: To obtain higher quality coconut products Mechanisation of dehusking nuts, technology for processing the different parts of the coconut, new products Greater use of its by-products

Increasing Yield

The perennial nature of the crop does not lend itself readily to experimentation. There has been little improvement in yield of the crop through systematic breeding efforts. Selection of mother palms has been based on visual basis and to a certain extent on actual yield records. Consequently, only illegitimaie seeds of unknown male parentage were available as planting material.

Early attempts at crossing talls with dwarfs in Malaysia gave variable results and did not generate much excitement. The success achieved with the Malayan Dwarf x West African Tall hybrid (termed MAWA in Malaysia) in the Ivory Coast has led to renewed interest in hybrids in early 1970. The MAWA grows and yields well on coastal clays (Varialingam *et al*. 1975, 1978; Ng and Chan, 1976; Chan, 1978, 1982) and on inland soils (Goh, 1982 and 1988). It has been adopted for large-scale planting until recently. Other coconut types (Markham, Rennel etc) have been imported and a wide range of dwarf x tall hybrids are being assessed.

The current average estate yield of 2 m tonnes/ha is far too low to sustain the industry. Even if the yield could be raised to 5 to 6 m t copra/ha (equivalent to 3.25 to 3.9 m tons of oil) with the optimum factors of production like best available planning material, high inputs of fertilizers and cultural practices, coconut is still unable to compete with the normal average estate oil palm yield of 20 t of FFB/ha under commercial cultivation (Table 5). To be viable as a monocrop, much higher yield levels are needed. A comprehensive list of coconut varieties with good yield and secondary characteristics together with a model coconut for Malaysia has been drawn up. Theoretical estimstes appear to indicate a high yield of 13 tonnes copra/ha could be achieved (Corley, 1985).

Table 5: Oil output from oil palm and coconut

Crop	Yield tonnes/ha/year
Oil Palm	
FFB	20.0
Palm oil (20%)	4.0
Palm kernel (5%)	1.0
Palm kernel oil (50%)	0.5
Total oil	4.5
Coconut	
Copra	6.0
Oil (65%)	3.9

Agronomic experimental work on local coconuts has been generally limited to fertilizer trials. Some results of trials by private sector and Department of Agriculture were largely negative (Belgrave and Lambourne, 1934, Wilshaw, 1941), while fertilizer trials in the 1970s & 80s on MAWA produced good responses (Vanialingam, *et al*, 1975 & 1978; Ng and Chan, 1976; Goh, 1982 & 1988). In the current competitive environment, the low input cultural practices should be discared. Potential yields can only be realised with correct nutrition and agronomic practices. Data on nutritional requirements, optimum planting densities and other cultural practices needed for the high - yielding hybrids which are in the pipe-line, are required to be researched.

Efforts to obtain a greater understanding on the physiological factors limiting growth and yield is being undertaken. It may also be pertinent to study photosynthetic production of dry matter including the nature of partitioning of photosynthate within the palm, as influenced by planting densities. fertilizers and water stress. The developmental physiology of inflorescence, fruit as well as button - fall also merit attention.

A rapid multiplication technique through tissue culture is needed to avoid the long time-span and other difficulties of cocouut breeding. Progenies could be raised vegetatively from elite palms.

Crop protection measures developed for oil palm will also be largely applicable to coconuts but consideration has to be given to the different biological and morphological characteristics of the coconut and to pest and disease problems specific to this crop.

Intercropping

This planting system has provided an effective solution to the problems of increasing the productivity of coconut land, ensuring greater and efficient utitisation of farm resources, increasing tne farm income and supplementing the food requirements of the small holders. Intercropping has also permitted crop diversification so that the risks are spread over a number of crops.

In estates, the underplanting of old coconut stands with cocoa saved them from being replanted with oil palm. Very often the profits from cocoa exceeded that from the coconuts. Trials are underway to determine the best combination of the two crops, to find a practical method to replace the poor yielding old coconuts and in the case of monoculture-cocoa, to replace the non-economic shade trees with the high yielding hybrids under the existing conditions. In new cocoa plantings where some permanent shade is required, the new hybrid coconuts have been planted.

Other crops suitable to be intercropped and underplanted and have great potential are coffee, bananas, vegetables and fruit trees. Undergrazing of livestock especailly sheep to control the weeds and to increase farmers income have proved to be popular.

Post-harvest Technology and Processing

This strategy is to efficiently decrease the cost of production and increase or add value to the coconut products and by-products. Products like bottled coconut water drinks, spray-dried coconut milk and coconut flour are a few of the new products being tested.

Improvements are being made to the prototype of the mechanica, dehusking machine. This machine has attracted attention from the estate sector considering that skilled worker for these jobs are scarce. The dehusking machine is easier to operate compared to the conventional chop and even a novice can easily operate it and quickly attain a comparable working rate (Zulkifli and Abdullah, 1982).

Developments in the aqueous processing of coconuts (Hagenmaier, 1982) in other countries are being closely monitored to determine its applicability to Malaysian conditions.

Work is also being carried out to make more use of the coconut by-products that are traditionally thrown away, such as coconut husk for coir fibre, coconut shell for activated carbon and charcoal and coconut water for food production etc.

BY-PRODUCT UTILISATION

The uses of coconut in Malaysia is presently limited to the production of copra, coconut oil and milk *(Santan)*. The raw by-products left after the process to obtain the above three main products are endosperm milk (water), husks and shell. The trunks and leaves are seldom used widely and during replanting are burned off.

The coconut water or endosperm milk is now experimentally bottled as a carbonated drink and the consumers' response is closely monitored. Coconut water has been shown to contain substance(s) capable of inducing rapid growth in tissue culture.

Limited use is made of husks into coir for brooms, brushes, cushion, paddings, beds, carpet underlays and gymnastic mats (Adinan, 1982).

In Malaysia, the use of shells for ornamental domestic and industrial purposes is of little importance. However, a considerable amount of the shells are used as fuel to dry copra in kilns.

Apart from the occasional use of the coconut trunks as temporary bridges in agricultural areas, the trunks are stacked and burned off, as decaying trunks are the main breeding grounds of the rhinoceros and other beetles. The coconut wood is seldom used in furniture utility items and curios.

Limited use is made of the petiole of the leaves into brooms while the young leaves are weaved into small pouches to be filled with rice and cooked.

The emphasis on by-product utilisation of coconut is sadly lacking. There is still considerable scope for improvement even in the end-uses of the coconuts, leaving aside the by-products.

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PRESENT STATUS OF COCONUT INDUSTRY AND RESEARCH IN SRI LANKA

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The Coconut Industry

Coconut occupies abcut 10,00,000 acres of land. The most important coconut growing area is called the "Coconut triangle" which comprises most of the districts of Kurunegala and parts of the districts of Puttalam, Colombc and Gampaha. Together, they account for nearly 70 per cent of the coconut lands. There are about 700,000 coconut growers, the majority of which are small holders. About 70-75 per cent of the holdings are below 4 hectares.

The Coconut processing industry consists of copra milling desiccated coconut manufacture, fibre and charcoal production. There are over 50 oil mills and over 60 DC mills. Over 800 fibre mills are known to exist. In all, the coconut processing industry provides direct employment to about 100,000 workers.

Coconut is a major source of edible oil and fat in the daily diet of Sri Lankans. The average per capita consumption is about 105 nuts per year. Coconut supplies about 22 per cent of the daily caloric intake of an average consumer and is a major source of calories, being second only to rice.

The coconut production in 1983, 1984 and 1985 had been 2312, 1942 and 2958 million nuts respectively. The value added as percentage GDP (in producing and processing) has been 4.2, 3.5 and 3.5 for these years. The average export price (FOB) per nut during these years had been Rs. 3.66, Rs. 6.48 and Rs. 3. 59 respectively, while the export earnings had been Rs. 1921, 2118 and 3093 million respectively.

The Coconut Research Institute - Historical aspects

In Sri Lanka, organised plantation activities in tea, rubber and coconut started with the dawn of the 20th century. The colonial government made a very significant contribution towards the establishment, management and maintenance of these plantations, the produce of which was geared for export. The managers associated with these crops were organised and influential and with the support of the high officials, they were able to impress upon the government of the day, the need for systematic research on these crops to improve the industries. This became a reality in the 1920's with the establishment in rapid succession of the Tea, Rubber and Coconut Research Institutes.

A d[illegible]te proposal for a Coconut Researc[illegible] under the Ministry of

Agriculture was made in 1923 and this led to the enactment of the Coconut Research Ordinance no. 29 of 1928. The first meeting of the Board of Governors took place on 27 April, 1929. The finances for the scheme were made available through a cess. The promulgation of the Coconut Research Amendment Act No. 31 resulted in the upgrading of the Coconut Research Scheme to the Coconut Research Institute in 1950.

The Coconut Research Institute began its activities with just three technical divisions- Genetics (sometime later named Botany), Chemistry and Soil Chemistry. Since then, there has been a progressive enlargement of activities resulting in the creation of more technical divisions and reorganizations.

The Coconut Development Act No. 46 of 1971 was promulgated after the establishment of the Ministry of Plantation Industries. Under this act, the Coconut Development Authority was established, which was charged with the responsibility of coordinating the functions of four satellite Boards, namely, Coconut Cultivation Board, Coconut Marketing Board, Coconut Processing Board and the Coconut Research Board. A further organisational change occurred in 1978 when the government established the Ministry of Coconut Industries, separate from the Ministry of Plantation Industries.

The Coconut Development Act No. 46 of 1971 defines the functions of the Coconut Research Institute as conducting and furthering scientific research in respect of the growth and cultivation of coconut palm, coconut-based cropping systems, preventing and controlling pests and diseases and establishing pilot plants for the processing of coco[illegible] products and by-products. Althou[illegible] CRI is not directly responsible for extension activities, it has a vital role in this sphere to advise the Coconut Development Authority and the Coconut Cultivation Board regarding developments in research and train their staff so that they could transfer the new technologies to the appropriate end-users.

Present Organisation of the Research Institute

The Coconut Research Institute is managed by the Coconut Research Board, the members of which are appointed by the Minister of Coconut Industries. The Board has three sub-committees, namely, the Research Committee to formulate the research programme in consultation with the members of scientific staff and also to monitor the progress of implementation of the research programmes, Administrative Committee to advise the Board on policy matters relating to the administration of the CRI and the Estates Committee to formulate the cultivation programme and to monitor its implementation.

The research activities of the Coconut Research institute are organized into eight divisions : Agronomy, Coconut Processing Research, Crop Protection, Genetics & Plant Breeding, Soils and Plant Nutrition, Biometry, Tissue Culture and Plant Physiology. These technical divisions are serviced by a Library, the Coconut Information Centre, Information Services Unit, the Administration Division and the Estate Management Division.

The main laboratories of the Ccconut Research Institue are located at Bandirippuwa Estate, Lunuwila and are well-equipped to conduct research in the relevant disciplines. In addition to this central organisation, the Institute conducts its activities at other field stations at Kirimetiyana Estate at Lunuwila and Pothukulama

Research Station at Pallama, Ratmalagara Estate at Madampe, Walpita Estate at Kotadeniyawa and the Adaptive Research and Demonstration Farms at Minneriya, Kalkudah and Nattandiya. The Institute also maintains three seed gardens, namely, Isolated Seed Garden at Rajakadaluwa, Makandura Seed Garden at Gonawila and Maduru Oya Seed Garden at Bogaswewa. The substations and seed gardens are about 2,200 acres in extent.

Although the Coconut Research Institute is not directly responsible for extension activities, it produces nearly all the advisory literature used by the Coconut Cultivation Board in its extension activities.

The Institute acts as a centre for the collation and dissemination of information on coconut to research workers in Sri Lanka and abroad.

Another imporant funct on of the CRI is to provide high quatity seed nuts to the industry. These are selected from the Institute's seed garden and from a pool of specially selected palms and are provided to the nurseries of the Coconut Cultivation Board.

Research Accomplishments

The Coconut Research Institute has an outstanding record of service to the industry. It is not possible to detail adequately and comprehensively all of the major achievements of the Institute since its inception. However, a few selected examples would suffice to indicate the magnitude of the Institute's contribution to the industry and that the investment on research has been amply rewarded.

Since 1958 when a pupal parasite *Trichospilus pupivora* Ferriere was first bred to control a severe outbreak of the coconut caterpillar, *Opisina arenosella* Walker, the emphasis in pest management activities with commendable foresight, has been heavily weighted towards biological control methods. The value of this technique was amply demonstarted when the coconut leaf miner, *Promecotheca cumingi* Baly. was inadvertently introduced to Sri Lanka in 1970. The pest was first recorded from Dehiwala and started spreading rapidly, primarily along the coast both to the south and north of the point of origin. An estimated 10,000 ha were severly affected. The entire coconut industry was threatened, particularly when the pest started advancing inland towards the main coconut triangle and established pockets of infestation around railway stations.

The strategy for the control of this pest included the import, laboratory breeding and release of two parasites. A consignment of parasites received from Singapore in late 1971 consisted of 24 unmated females and 10 males of the larval parasite *Dimmockia javanica*. Laboratory breeding of this parasite proceeded smoothly and a total of 147,000 adult parasites were released in the pest-affected areas. The parasite *D. javanica* was very active in the field. There was a very rapid and massive build up of the parasite population in the infested areas. The pest population declined steadily, and within two years the infestation was brought completely under control. This parasite is firmly established and keeps the pest under effective control.

A larval-cum-pupal parasite *Pediobius parvulus* was imported in mid-November from Indonesia and a pure culture of this insect was released in January, 1972. The bulk of the releases was done during the first half of 1972.

The saving to the country has been tremendous. In early '70s the total export value of coconut was in the region of US $ 50 million. Today, it is about 80 million. Considering that only about 30 per cent of the production is exported, the pest could have completely wiped off the exportable surplus.

The pest was controlled within two years, and the loss at that time is estimated to be 20 million nuts. The cost of the entire biological control programme was about Rs. 300,000. which has now made an annual saving of at least US $ 80 million. The cost of insecticidal control at that time was estimated to be about Rs. 3 million per round of spray, i, e. 10 times the cost of the entire biological control programme. Since biological control is self-perpetuating with no recurrent costs, the long term saving is inestimable.

Some of the pioneering work for the genetic improvement of the coconut palm was initiated with the inception of the Coconut Research Scheme. Initial studies were directed to identify suitable criteria for selection of a seed parent in order to provide improved planting material. Long term observations and analyses of data led to the estimation of heritability values of important characters such as yield of copra, weight of husked nut etc. of the palm. Based on this genetical information, a vast programme of mother palm selection was carried out.

Both intra-and inter-varietal crosses were studied in a hybridization programme. In intravarietal crosses, the outstanding achievement has been the *typica* X *typica* (CRIC 60) cross. *Typica* X *nana* crosses were also introduced during this period and the first coconut seed garden at Ambakale for the mass production of improved planting material was established in 1955. Initially, this seed garden produced *typica* X *typica* (CRIC 60) seednuts, but subsequently dwarfs were introduced in order to produce *nana* X *typica* (CRIC 65), which gave outstanding yields under good management and good soil and climatic conditions.

One of the first statistically designed field experiments on fertilizer in Sri Lanka was laid out in the 30's. The results of this and several other long term field experiments on fertilizer indicated the importance of potassium, not only for nut production but also for better copra outturn. These trials have also elucidated the roles of nitrogen and phosphorus. Experiments conducted in the 50's indicated that the cheaper method of surface application was as good as the traditional trench method. Several elegant experiments in the 60's using radio active materials provided valuable information on the effective root zone and the uptake of fertilizer and led to precise recommendations on the placement and application of fertilizer.

Important contributions in product technology include the design of Ceylon Copra Kiln, which produces high quality copra, 'generator process' for the conversion of toddy into high grade vinegar, methods for the preparation of treacle, jaggery and sugar on cottage scale and the preparation of non-alcoholic and alcoholic beverages with coconut sap as the base material.

Several pastures from similar ecological regions of the world had been introduced and these were rigorously tested in the field at several locations in the coconut growing areas. Based on the results, several pasture and fodder grasses, namely, *Brachiaria miliiformis,* *B. dictyoneura, B. ruziziensis, Panicum maximum* and *Setaria* sp. have been identified as suitable for growing under coconut in wetter areas. Techniques for the establishment and management of legume - grass mixtures have also been worked out.

Current Research Programmes

The Institute launched a five year research programme in 1984 based on a number of high priority research projects. These projects were identified after having taken into consideration the need for developing a programme that is dynamic and adaptable to the changing conditions. The main objectives of the programme are to increase the national coconut production, reduce cost of production and increase productivity from coconut holdings. Accordingly, the following projects were identified:

> Improvements to soil organic matter status and water holding capacity; Rehabilitation of ow yielding plantations; Establishment and management of new plantings/ replantings and underplantings; Studies in Field Management Systems; Production of improved varieties; Production of high quality seed and seedlings; Nutrient requirements of coconut, particularly under stress conditions; Population dynamics of the pest / parasite complex of the coconut caterpillar; Evaluation of systemic insecticides for the control of foliar pests of coconut; Studies on the pests of inflorescence; Biological control of black beetle, Physiology of the coconut palm; Premature decline of palms; Application of biometry in coconut research; Vegetative propagation of coconut; Intercropping Biology, behaviour and control of the red palm weevil; Improvements to copra manufactering process with fuel saving techniques; Coconut fibre technology and Irrigation.

The progress of the implementation of this research programme is very satisfactory. Nearly 100 experiments are in progress. Majority of the experiments are of long term nature and the final outcome will be known after the experiments progress for the full period.

Some of the results of these experiments, which are now available to the industry, are indicated below:

Results from the experiments on cover cropping have been most encouraging. Soil improvement through the addition of organic matter from cover crops was significant. These experiments enabled the evaluation of ground and bush covers for their suitability for coconut lands in the different agroclimatic zones. and to demonstrate their usefulness in improving the soil. These experiments also demonstrated the soil moisture conversion by the cover crops. From these studies, it could be generally concluded that *Mucuna*, Siratro, *Pueraria, Calopogonium* and *Centrosema* are the most effective cover crops.

The advantages of intercropping were demonstrated in experiments conducted in the wet zone. It has been clearly shown that growing cocao, pepper, clove, cinnamon and annuals has no adverse effects on coconut, provided coconuts and the other crops are managed properly. In fact, cultivation of cocao, coffee and cinnamon as intercrops in coconut substantially increased the coconut yields. These trials have also shown the economic advantages of intercropping and the potential for maximising income from coconut lands.

Significant progress was made in the attempts to develop varieties with adaptation to a wide range of environments. It has been possible to identify palms which would perform well in good years as well as in unfavourable years. Methodology for pollen collection and processing was upgraded with the acquisition of modern equipment. Experiments have also clearly demonstrated the usefulness of the introduced variety, San Ramon as a source of improved material. The first generation palms of San Ramon x San Ramon have flowered in about four years, giving 350 g copra/nut.

The fertilizer recommendations were revised and a single mixture was introduced for the entire country. The rates of application are adjusted according to the fertility of the soil and climate. The methodology developed to determine the nutrient status of palms using leaf analysis data and thence to rationalise fertilizer usage is being tested in the field.

Considerable progress was made in introducing new techniques for pest monitoring and control. It has been possible to make a preliminary identification of the sex-pheromones of the coconut caterpillar, which can be used in the field in traps to monitor pest position in an early warning system.

The novel techniques of introducing systemic insecticides into the coconut palms, namely, root feeding and trunk injection for the control of foliar pests were field tested on a large scale and found to be very effective.

Considerable progress was made in perfecting the techniques of embryo culture. These techiques are now used in laboratory tests to screen varieties for their ability to withstand moisture stress and to produce seedlings of 'Dikiri pol'. Somatic or vegetative 'seeds' have been produced from leaf tissue using the tissue culture techniques. A plant has been produced successfully from a meristem but multiplication or cloning have not been successful yet.

Recent experiments have clearly indicated the usefulness of the leguminous bush cover, *Glyricidia* spp. as a source of nutrients and for soil amelioration. About 30 kg of leaves of *Glyricidia* provide the total annual requirement of nitrogen for the coconut palm. It also improves the moisture holding capacity of the soil.

Work on the hitherto-unused coir dust as a medium for moisture conservation has also given very encouraging results. Experiments have clearly demonstrated the value of coir dust in moisture conservation and its ability to increase coconut production, particularly in the drier parts of the country.

Sri Lanka's coconut production has fluctuated widely during the past several years, primarily due to adverse weather conditions. The Institute's current research programme lays heavy emphasis on work on overcoming drought effects and maintaining stable yields by the use of new varieties, moisture conservation methods, irrigation etc. The results obtained so far have been most encouraging, and accordingly, it is hoped that the coconut industry could be improved considerably. □

STATUS OF COCONUT RESEARCH, DEVELOPMENT AND UTILISATION IN TANZANIA

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The coconut is believed to have originated from South East Asia or Micronesia (Harries, 1977; Purseglove, 1968; 1972) and came to the East African Coast via India or Sri Lanka. Historical trade connection between Asia and Africa, indicated by the discovery of Chinese coins of the eighth and ninth century at Kilwa and Mogadishu (Revington, 1936) and at Mafia (Robinson, 1937), perhaps brought coconut to the east coast of Africa (Kaiza, 1987). When the Arabs arrived in Zanzibar in the tenth century, the existence of coconut palms had already been recorded at Malindi north of Mombasa in Kenya (Purseglove, 1968). In Tanzania, coconut planting was probably promoted first by the Arabs in Kilwa and extended to Rufiji and Kisarawe. Secondly, by the Germans, particularly at Tanga region during their administration of the then Tanganyika between 1891-1914. Thirdly and perhaps the most significant coconut expansion was promoted during the British rule after the first world war. Between 1918 and 1946, coconut planting was expanded in the Tanga and Pangani districts, mainly in the coastal belt of Mkinga, Gombero and along the Pangani River replacing sugarcane plantations (Swynnerton, 1946).

Ecological factors Vs. Coconut Cultivation in Tanzania

For coconut, the favourable climatic conditions exist within 20 degrees north and south of the equator. In the coconut growing areas of Tanzania, sunshine, temperature, relative humidity and wind velocity are favourable (Wuidar, 1980). The most important limiting factor in the successful cultivation of coconut is rainfall (Agrar-und Hydrotechnik GmbH, 1980). Even in areas of high rainfall such as Pemba, Mafia and Zanzibar with annual means over several years of 2166 mm, 1731 mm, and 1590 mm respectively, experience severe drought during some years due to poor rainfall distribution resulting to 5-8 months of varying degrees of water deficit per year. In Lindi region, a mean of only 953 mm annual rainfall is not uncommon with about 9 months of water deficit. Nonetheless, coconuts are mainly grown in low lying areas where high water table compensates for low rainfall.

Soil conditions vary widely. More basic parent materials and various limestones have given rise to red, highly oxidic friable clays, classified as Rhodic or Orthic

Ferassols (FAO. 1974). In more acidic and coarse-grained parent materials such as marls of the sandstones, the main soils are deep, reddish Luvisols or Acrisols. The really coarse grained parent materials produce pale coloured deep sands, classified as Arenosols. Some of these deposits have humus mobilisation and redeposition, so that there are also Orthic and Humic Podzols. The fine textured shales and marls give rise to extensive areas of dry cracking clays and also to imperfectly and poorly drained soils (Gleysols). Gleysols occur on all parent materials where there is water-logging. In Zanzibar, Carlton *et al.* (1955) identified three main soil groups: *mchanga* - a catenary related group derived from non-calcareous sediment; *kinongo* - red or potentially red soils of varying age derived from limestone and *kinano* - a miscellaneous group of heavy soils, derived from clays and marls.

Agricultural sector, coconut and the economy

The agricultural sector contributes 85% to exports, accounts for 40% of gross national product and supports 90% of the population. It is a major source of food and raw materials for the urban and industrial sectors. The agricultural population is also an important market for the goods and services produced in the industrial sector. Agricultural development is, therefore, crucial to achieve the objective of employment, income distribution, sustained growth and self-reliance on which the government has laid great emphasis.

Coconut is a crop of vital importance within the agricultural sector and the national economy as a whole. It plays the role of : 1) income earner for the farmers in the rural areas of coastal Tanzania, where 15% of the country's population live; 2) source of vegetable oil in people's diet in rural areas; 3) import-saver through supply of vegetable oil for the urban consumers; and 4) on the long-term, a potential foreign exchange earner for the nation through exports of copra. oil and other coconut products. Coconut is abundant in the coastal belt, from Tanga to Mtwara and in the islands of Zanzibar, Pemba and Mafia. It occupies about 240.000ha with 22.6 million trees, one-quarter of which is found in the islands. The crop is produced basically by the small holders (95%), the rest by medium and large scale commercial growers. Mean annual production is reckoned at 23 nuts per tree/year.

About one-third of the production is used for subsistence, the rest is largely sold as fresh nuts, except in Zanzibar and in Mafia (Mafia Coconuts Ltd - MCL) where copra production and oil processing are still done. The crop provides some 40% of the total vegetable oil in Tanzania making it the single most important source of this oil. Market projections of the vegetable oil sector show that the present demand is much higher than the quantities available. Approximately, one-half of the requirement is not met. With the rapidly increasing population, this deficit would continue to exist unless the coconut output will be more than doubled by the year 2010. Any growth in per capita income would further widen the gap between supply and demand. This condition promotes a highly favourable socio-economic climate for the promotion of coconut, which has been characterised by a down-trend in production as a result of various factors : 1) generally low level of cultural management, especially with small holders; 2) presence of overaged palms that are declining in production; 3) poor quality planting materials; and 4) the incidence of insect pests and a lethal disease. These factors are further aggravated by the low rainfall pattern (except in Pemba, Zanzibar and Mafia) compared to other coconut growing countries (Balingasa, 1984).

The National Coconut Development Programme was launched by the Government to arrest further decline in coconut production and productivity and also to further promote the coconut industry.

The National Coconut Development Programme

The National Coconut Development programme (NCDP) began in 1979 with the external assistance from the Federal Republic of Germany (FRG). Initially, it was intended to develop disease and pest control measures, to examine the potential for introducing improved varieties and production of quality seednuts and planting materials, train Tanzanian staff in husbandry and extension methods and support the coconut field advisory activities. Later, a Coconut Pilot Project, appraised in 1980 - effective in 1981 and with financial assistance from the International Development Association (IDA) of the world Bank was designed in close collaboration with NCDP to finance: 1) agronomy trials; 2) improved maintenance and rehabilitation trials and 3) technical assistance required for the implementation of the trial programme, consultancies, training of local staff and preparation of the planning documents for the next phase of the coconut development programme.

To avoid overlapping and ensure cost-effectiveness, and to achieve close cooperation and coordination between the FRG and IDA-financed activities, IDA accepted the proposal of the Tanzanian Government that the Coconut Pilot Project would become part of NCDP. It was further agreed that the German Agency for Technical Cooperation (GTZ), which already implemented the FRG-supported component, should undertake management of NCDP under the overall responsibility of the Ministry of Agricultural and Livestock Development (MALD).

NCDP is managed by a Coordination unit under the overall responsibility of the MALDs in the mainland and in Zanzibar. This Coordination Unit, supported by a small planning section, organises budgeting and accounting. It is responsible for manpower planning and development and general administration, including procurement. A technical service section - equipped with the basic infrastructural facilities, tools and equipment, caters to repair of vehicles and equipment, with maintenance services at headquarters and field stations.

On the agri-technical aspect, the works done so far and the major results achieved can be classified into: 1) production promotion; and 2) research activities.

PRODUCTION PROMOTION

Development and operation of seed gardens

Two seed gardens, one in Mafia Island and the other in Zanzibar were developed and operated to produce hybrid seednuts. These seed gardens were designed to adopt the "assisted pollination" technique of hybrid seednut production, characterised by separate solid block planting of mother and father palms. There is a built-in flexibility in such a design. A mere shift in the variety of pollen brought into the mother palm sites will produce a different hybrid. Thus, the lifespan of the seed garden is not out-moded with the discovery of a new or better hybrid, provided that the same mother palm variety is involved. Furthermore, there will be higher hybrid seednut output per unit area, in as much as more mother palms are planted per unit area. The varietal spectrum in the seed gardens is indicated in Table 1.

Table 1: Varieties in the seed gardens and their coverage in the year 1988*

Variety	Area in hectares		Total
	Zanzibar	Mafia	
Mother palms **			
MYD	31.61	35.00	66.61
CRD	9.98	11.41	21.39
MRD	9.98	11.00	20-98
BGD	2.41	1.70	4.11
SGD	4.74	0.00	4.74
PRD	1.93	0.00	1.93
Sub total	60.65	59.11	119.76
Father palms ***			
EAT	8.73	9.27	18.00
WAT	8.95	6.47	15.42
RLT	0.73	0.77	1.50
PYT	3.44	4.50	7.94
KPT	0.00	0.76	0.76
MLT	0.00	0.76	0.76
THT	0.00	1.22	1.22
Sub total	21.85	23.75	45.60
Grand total	82.50	82.86	165.36

* — Missing palms deducted

MYD — Malayan Yellow Dwarf
CRD — Cameroon Red Dwarf
MRD — Malayan Red Dwarf
BGD — Brazil Green Dwarf or EGD (Equatorial Guinea Green Dwarf)
SGD — Sri Lanka Green Dwarf
PRD — Pemba Red Dwarf

** — 205 palms / ha
*** — 143 palms/ha (Talls)

EAT — East African
WAT — West African
RLT — Rennell
PYT — Polynesia
KPT — Kampuchea
MLT — Malayan
THT — Thailand

The seed gardens currently produce hybrids mainly of two types - MYD x WAT and CRD x WAT - hybrids approved for release. Production of hybrids started in 1985 (Table 2). Initially, pollen for the seed gardens had to be imported. But from 1987, some pollen was produced locally and in 1988, the seed gardens became self-sufficient in its pollen need. The pollen import had ceased thereafter.

The 1985 yield in Zanzibar was considerably reduced due to the major damage caused by *Pseudctheraptus wayi* Brown. Without implementing chemical control measures, hybrid seed production would have been practically nil in Zanzibar. This insect pest can really inflict very serious damage. Biological control measure of this insect pest using a predator ant species *Oecophylla longinoda* appears to be promising, but the level of colonisation is just not enough to provide sufficient protection for the developing buttons. At peak production, granting that *P. wayi* damage can be contained and hybridization done on all seed parent palms, the combined seednut production capacity can reach about one million per year. Depending upon environmental factors - mainly rainfall, tremendous yield fluctuations can be experienced. Nevertheless, under such seednut production capability, it is practical to assume that seednut requirement for future planting can be adequately met.

Provision of East African Tall seednuts

The base coconut variety in Tanzania is the East African Tall (EAT). It is a rather variable coconut population exhibiting distinct morphological and nut features typical of: 1) the Mozambique Tall (MZT); and 2) the West African Tall (WAT). The former has prominent shoulders and the segments are flat. The latter, on the other hand, exposes a ridge along the equatorial diameter of the nut when dead-ripe.

NCDP advocates the planting of both EAT and the hybrid. Thus, there is a need for large quantities of quality EAT seednuts. To guarantee this, a simple and practical mass selection technique has to be followed. In the long-run, EAT seednuts can be supplied from individually selected palms based on phenotypic choices, yield records and nut component data. In this case, the heritability values of certain characteristics are considered in deciding on the criteria of choice. However, one major limitation of individual palm selection is the low quantity of seednuts obtained, so that under high demand, it may not be possible to meet the requirement adequately.

The final solution, however, in the supply of quality EAT seednuts is the development of an EAT seed garden. To date, a first cycle of EAT selection had

Table 2 : Hybrid seednut production in the seed gardens 1985 - 87*

Seed Garden		1985	1986	1987	Total
Zanzibar		10,939	105,982	355,914	785,571
Mafia		195,466	89,572	500,533	472,835
	Total	206,405	195,554	856,447	1258,406

* Gross figures, rejects account for about 30%

been carried out and palms were field planted in an aggregate area of about 20 ha. From these palms a second selection which must take into account the precocity in flowering and resistance to pest and diseases, can be done. Thereafter, a new EAT seed garden can be established as a permanent source of improved EAT seednuts.

Extension services for coconut growers

General extension services in Tanzania is directly functioning under the two MALDs-one for Mainland Tanzania and the other for Zanzibar. Under NCDP, extension services are relegated to its organisational component called Coconut Extension Services (CES). The CES plays the role of a catalytic agent towards achieving increased coconut production through campaigns for adoption of appropriate cultural and management practices relevant to the rehabilitation of existing coconut groves and the establishment of new plantations. In the case of the latter, CES is involved in providing quality planting materials by assisting in the selection of EAT seednuts and promoting the planting of hybrid materials, a direct output from NCDP's seed gardens. Adjunct to this, CES provides technical assistance in the operation and management of non-NCDP nurseries to ensure the production of quality seedlings. The CES does not have its own extension organisation in the field. It functions as subject-matter specialist for the general extension service of MALD which provides the direct linkages with the coconut growers (NCDP, 1987).

Extension service in coconut involves some 300,000 coconut growing families which generally adopt a mixed-cropping system, farm sizes varying from one to about ten hectares. There are few plantations, estimated to cultivate not more than 5% of the total palm population. The working area of CES covers five regions with 25 districts in the mainland and 10 districts in Zanzibar (Unguja and Pemba).

Research Activities

Research activities in coconut are presently confined to the areas of agronomy, breeding disease, insect pests, and farming systems research.

Agronomy Research

Trials in agronomy research were started in 1981 and these relate to aspects of fertilizer/plant nutrition, variety/hybrid testing and cultural management. These trials are carried out in nine trial sites selected as typical of seven major potential coconut growing areas : 1) red-brown sandy loam (Mkuranga); 2) coastal sands (Chambezi / Kange); 3) brown-red clay (Maramba / Mlingano); 4) red sand clays over corals (Boza); 5) alluvial (Ng'apa); 6) sandy loam (Zanzibar) and 7) red clays over corals (Zanzibar). In addition, agronomic performance of varieties and hybrids in the disease resistance trials are recorded.

Plant nutrition

Among trials related to fertilizer/ plant nutrition on Mainland Tanzania, some interesting results were obtained (Romney, 1987).

In the red-brown sandy loams, nut production was increased substantially by phosphorus and less by nitrogen. Nut size was increased by potassium and complete cultivation produced more nuts than large weeded circles. At the price level of 1987, fertilizing with P and complete cultivation were the most profitable practices.

On coastal sand, nut production was increased by N and K, also by complete cultivation rather than patchy weeding. Nut size was increasec by K. Palm wilt caused by the drought of 1985-86 was less in plots where K was applied under complete cultivation.

On red-brown clays, nut production was improved by N on hybrids, but only in the absence of lime. EAT previously over-fertilized with sulphate of ammonia responded to lime, nut size also improved. On all fields, complete cultivation was much better than weeded circles

In Zanzibar on *Kichanga* soil (sandy-loam), it was noted that precocity and early bearing of MYD X WAT hybrids were improved by N and P. Among palms planted in April 1981, by December 1986, 12% more bunches were produced when N or P were applied. The number of nuts tended to be greater with P in 1986, but nut-set data at June 1987 did not show clear fertilizer response due to *P wayi* interference. Nut size averaged 5.1 nuts/kg copra. On Kinongo soil (red clay), growth and precocity of MYD X WAT hybrids and EAT were enhanced by N and K together. Lack of K caused marked leaf deficiency symptoms accentuated by N.

Variety/hybrid trials

Evaluation of various planting materials (mainly hybrids) was started in April 1981 and some results have been obtained (Table 3).

In general, the various dwarf x tall hybrids were equal in their performance. There was no indication that EAT or MLT crosses were inferior than WAT, RLT or PYT crosses. The WAT x RLT hybird was less

Table 3: Bearing palms (6/87) as percentage of MYD x WAT at Mkuranga, Chambezi and Bambi variety trials I and II.

Variety	Mkuranga	Chambezi	Maramba	Bambi	Mean*
MYD x PYT	129	98	107	93	107 a
MYD x SLT	45	143	138	109	109 a
MYD x WAT	100	100	100	100	100 a
WAT x SGD	—	—	104	90	
CRD x WAT	51	95	132	139	104 a
EGD x EAT	68	83	134	106	97 a
MRD x WAT	147	105	116	91	115 a
CRD x PYT	28	38	125	134	83 ab
MRD x PYT	131	96	82	101	103 a
CRD x RLT	49	55	77	143	81 ab
EGD x WAT	38	98	132	123	98 a
CRD x EAT	51	98	123	149	105 a
WAT x RLT	59	75	21	25	45 bc
EAT	32	53	25	3	28 c

* Means followed by the same letter are not significantly different

precocious than the dwarf x tall hybrids, but the nuts were larger. The tall varieties, to date, performed much more poorly than any dwarf x tall hybrid and usually less promising than WAT x RLT. There was a tendency for RLT to be better than other talls.

Cultural management

It was noted that field planted polybagged seedlings were 15 and 11 per cent larger than bare-root seedlings at 22 and 34 months after planting respectively. On all soils, except red-brown sandy loam where P deficiency occurs, weed control by cultivation was more effective than fertilizer. Under intercropping with banana, maize, pineapple, green gram, sweet potato and cowpea, growth and bearing were much improved on all soil types. However, only maize on red-brown clays was reliably profitable.

Breeding Research

Little has been done on coconut breeding research in Tanzania. In the 1930's, a selection work on the EAT was undertaken in Zanzibar (Johns, 1938). Unfortunately, the progenies planted as a result of this selection are nowhere to be found. In 1960's, another selection work was pursued in Chambezi and selected progenies were planted which are presently maintained for further breeding work. In Tanga (1970's), the first step to coconut improvement through hybridization was initiated crossing EAT x PRD and a hybrid trial was established to evaluate the performance of the hybrid. It was clearly evident that precocity of the dwarf was transmitted down to the hybrids and the hybrids showed definite yield advantage over the conrol EAT.

With the creation of NCDP, further selection was done on the EAT population. In connection with the establishment of seed gardens, EAT selection was initiated in Mafia in cooperation with MCL. From some selected palms pollen were collected to produce crosses with EAT, hybrids of which are now being tested. A survey for coconut genotypes was undertaken in the major coconut growing areas (Balingasa *et al.*, 1981). Three dwarf coconut populations, namely: Pemba Red Dwarf, Malayan Yellow Dwarf and Malayan Green Dwarf were identified. It was observed that in the EAT population, a great deal of variability existed among nut component data. Mean copra per nut was 175 g equivalent to 5.7 nuts/kg of copra. Resulting from this survey, six locations-four in Zanzibar and two in Pemba, were identified as promising EAT sub-populations and observed further for palm yields and nut component characters. At the same time, observation at MCL and Chambezi among selected palms based on pure phenotypic choices was carried out. Progenies from selected palms of the EAT sub-populations observed in Zanzibar and in Pemba were planted in Bambi Kidichi, and Zanzibar. From the observation at MCL, palms were selected as seednut sources for the establishment of pollinator palms in Mafia (Tirene) and in Zanzibar (Bambai), aggregating to more than 15 ha. Further selection is contemplated from these planted progenies out of the first selection cycle. From Chambezi, a number of palms were selected as interim seednut sources for small scale EAT planting.

As part of the establishment of the seed gardens, the conduct of variety trials and the test for resistance to the lethal disease, a number of coconut varieties were introduced (Table 4). Among the crosses involving EAT, pollen from EAT was provided by NCDP for producing hybrids at IRHO, Port Bouet, Ivory Coast, since the dwarf mother palms planted in the seed gardens did not flower by then. Expected to be received in 1988/89 from IRHO are Panama Tall, Kar Kar Tall, Tagnanan Tall and Rotuma Tall. It is planned that the various introductions not included in the present disease resistance trials are also exposed to the disease to identify possible sources of resistance. Varietal resistance may be the only plausible solution to the lethal disease problem. Furthermore, it is also hoped that varieties/ hybrids which can reasonably tolerate drought conditions can be found.

One breeding station is being established in the Mainland at Chambezi. Complementary to this are the established seed gardens in Mafia and in Zanzibar which will play a great role in producing the hybrids using the already established varieties. In the future, it is envisaged to pursue activities concerning genetic combining ability testing, establishment of genetic trials and research on appropriate breeding techniques to support the seed production units. It is likely that EAT will play a dominant role in the future conduct of breeding research.

Disease Control Research

It is believed that for at least 80 years now, a destructive disease exists in Tanzania mainland. Reports about the disease are contradictory. A disease

Table 4 : Present coconut germplasm in Tanzania (1988)

No.	Dwarf	Tall	DxT/TxD	T x T
1	MYD (IRHO)	WAT (IRHO)*	MYD x WAT	RLT x WAT
2	MRD (,,)	RLT (,,)	MRD x WAT	
3	CRD (,,)	PYT (,,)	CRD x WAT	
4	SGD (,,)	MLT (,,)	BGD x WAT	
5	EGD (,,)	KPT (,,)	MYD x EAT	
6	MGD (,,)	THT (Thailand)	MYD x PYT	
7	—	NHT (,,)	MYD x NHT	
8	—	King Coconut (Sri Lanka)	MYD x MLT	
9	—	EAT (Tanzania)	MRD x EAT	
10	(Tanzania local)		MRD x PYT	
11			CRD x EAT	
12			CRD x RLT	
13			CRD x MLT	
14			CRD x SLT	
15			BGD x EAT	
16			BGD x NHT	
17			WAT x SGD	
18			MRD x MLT	
19			MYD x SLT	
20			CRD x PYT	

* Sources are indicated in parentheses

called *Herzfaule* (heart rot) was reported as early as 1905 near Bagamoyo showing symptoms such as premature nutfall, blackening of opening inflorescences and rot of the central leaves (Schuiling, 1987). Bacteria were considered to be the cause. *Herzfaule* was responsible for serious losses in adult and young plantation near Miwara in 1912-14. Bock *et al.* (1970) described a disease (Lethal Bole Rot) from the coast of Kenya and Tanzania, characterised by a primary bole rot followed by frond wilt and crown rot. The fungus *Marasmiellus cocophilus* was implicated as the cause. It occurs predominantly on seedlings and young palms up to 8 years old. In Tanzania, it was reported to be most damaging in Kibiti, Pande and Rushingi. Steiner (1976) investigated a disorder near Tanga. However, he observed no rot in the heart of the bole. The most typical symptoms were drying up of successively younger fronds with the midribs breaking and the arrest in growth of immature inflorescences. Rickettsia like organisms were associated with the disorder. Steiner reported symptoms similar to Lethal Yellowing (LY) from Bagamoyo, Kibiti, lower Rufiji delta and Pande.

With the formation of NCDP to promote the coconut industry, a section for disease control was set up during 1979.

Symptomatology of Lethal Disease

Since 1980 many coconut palms of all ages, in various stages of the disease, were dissected and symptoms recorded. Symptoms were consistent in all affected areas and very similar to those of the LY disease reported from the Caribbean and some part of West Africa. These were premature nutfall, bronzing of successively younger leaves, blackening of inflorescences, necrosis and rot of the spear leaves and decay of the root system, in that order (Schuiling *et al.*, 1981). Symptoms in non - bearing and bearing palms were similar, though restricted in range. The palms invariably die, the syndrome lasting 2-3 months in young palms and 5-7 months in mature palms. Palms are rarely infected before the age of 2 years. As co-identity with LY cannot be proven it was decided to name the disease-Lethal Disease (LD) of coconut palm.

From the numerous palms dissected, no bearing palm on the mainland showed a bole-rot as described by Bock (1970). In non-bearing palms such a rot was occasionally observed but only in advanced stages of LD, certainly not primary bole-rot. It is uncertain whether Lethal Bole Rot disappeared from Tanzania or never existed at all (Schuiling, 1987). Symptoms as described from Tanga by Steiner *et al.* (1977) were occasionally observed but always associated with drought. Symptoms described in 1900's and by Steiner in 1976 are consistent with the symptoms for LD described above, indicating that LD has existed in Tanzania for a long time.

Etiology of LD

Search for the causal organism of LD was done in cooperation with the Institute for Plant Disease, University of Bonn. Tissue samples from diseased palms were sent to Bonn for investigation with the electron microscope (EM) and ultrafluorescence microscope (UF). Work with UF was done in Tanzania as well. After initial negative results, mycoplasma-like organisms (MLO) were found in diseased palms, never on healthy palms (Nienhaus *et al.*, 1981). It appeared that MLO could only be detected if the EM work was focused on tissues with DNA accumulation in the phloem as demonstrated with the UF using DAPI, a fluorescent dye which reacts with the DNA of invading micro-organisms to form a fluorescent complex. The simple DAPI-technique was then used as a pretest facilitating the cumbersome and quantitatively restricted work in the EM. No bacteria, Rickettsia-like organisms or fungi were isolated from diseased palms. The spotting of MLO means that these organisms are likely to be the cause of LD, though this cannot be proven yet. This, investigation is in progress.

The injection of both bearing and non-bearing diseased palms with tetracycline-hydrochloride antibiotic resulted in the remission of symptom but only if injection was started in sufficently early stage of LD. Total remission of symptom was observed in one bearing palm only, the other recovering palm showed delayed symptom development compared with their controls and succumbed later. Tetracyclines are antibiotics which act against MLO. These results taken in conjunction with the finding of MLO in disease palms support the concept of a MLO-etiology for LD (Kaiza, 1987). However, it is not intended to use tetracycline as a control method because remission of symptoms was only temporary and it is highly uneconomical.

Recently, the planthoppers *Myndus crudus* and *Myndus taffini* were implicated as vectors of coconut diseases elsewhere. Insect population studies at seven LD-affected sites revealed that the insect species on coconut in Tanzania are virtually planthoppers as well. Twenty nine different species were identified at the CAB Institute of Entomology of which only seven were common at all sites. These seven species are the most likely candidates as vectors of the agent causing the LD. In transmission trials to find the vector of the LD, only one test plant developed symptoms of the disorder similar to LD. However, for several reasons the case is doubtful and has to be confirmed.

Epidemiology of LD

LD occurs only on the Mainland Tanzania. The severity of LD incidence in affected areas varies greatly from low activity to rampant disease, a phenomenon with no concrete explanation as yet. Low incidence in old EAT groves does not necessarily tally with low activity in young plantings. At several trials and private plantings, alarming losses occurred on young plants while they were low or nil in the mature surrounding palms. Even where LD is rampant, the rate of spread is comparatively low. New outbreaks were observed but often did not become established. Unlike the agressive spread of LY with frequent "jumps", LD spread slowly without 'jumps' (Schuiling, 1987). Newly diseased palms are recorded periodically in five extension fields of mature EAT and all young plantings of NCDP in diseased areas. Early observations indicated that : 1) LD causes the heaviest loss in the periphery of coconut groves, in particular where they are exposed to the prevailing wind; 2) that young plantings surrounded by other palms or bush are less quickly infected; 3) that symptoms occur predominantly from December till June; and 4) shading by mature palms decreases the rate of infection in young plantings.

Search for LD - resistance

Research on the LY for the last three decades indicated that the most important, if not the only way to control the disease is the search for resistant varieties. Therefore, disease resistance trials were established at six different LD - affected areas, naturally exposing the various varieties to the disease as this is the only way, so far, to test their resistance (Table 2). The EAT was used as a local control. It was noted that the hybrid MYD x WAT is not promising as to resistance, There was no certainty that other hybrids would perform better (Schuiling, 1987). Incidence of LD during 1986-87 had increased heavily in the trials. Losses in the MYD reached 19.7 per cent in Kifumangao while MRD showed 4.8 per cent incidence. The Brazil Green Dwarf performed worst with 30.6 per cent loss. The CRD at 10.0 per cent loss and SGD at 12.6 per cent need further observation. There appeared to be little differences in losses between the talls and the hybrids, indicating that satisfactory resistance in the dwarfs may not exist. Nevertheless, these reactions of the dwarfs and the hybrids must be interpreted with caution. The dwarfs and the hybrids are more precocious than the talls and may have reached the susceptible age earlier. Losses may level off or lessen in degree with age in the hybrids and perhaps increase in the talls as the talls reach a physiologically susceptible stage. In the light of current results, it is important to extent LD - resistance testing to other varieties. On the EAT, great differences in losses among the various disease areas indicate that possible resistance may exist in the local EAT population. The best performing tall in relation to the LD disease was noted with EAT collection from, LBS Tanga. Loss was at 3.0 per cent against 38.5 per cent loss with the worst entry in the trial at Pongwe, Tanga, It was therefore, decided to intensify search for LD-resistance in the EAT population.

Other disorders of coconut in Tanzania

In the nursery, it was observed that blast, dry bud rot and leaf spots are common diseases. Blast caused significant loss in one nursery, where it was observed most active from August to October. Perhaps, the incubation started as early as July. Other disorders such as weakening of the palms and loss of turgidity were observed to be pure physiological disorders ascribed to extreme cases of drought.

Pest Control Research

Pest control research concentrated on two major coconut pests, namely; the beetle - *Oryctes monoceros* Oliv. and the coreid bug - *Pseudotheraptus wayi* Brown. Initially, work was focused on the beetle, damage of which can be observed on palms of all ages. In plantations the beetle may turn into a serious pest when attacking young palms. The impact of beetle damage on young palms is much higher and can lead to death of the palms. Among bearing palms, economic damage is more manifested as reduction in yield due to destruction of green leaves, thus reducing photosynthetic capability of the palms. On both pests, the beetle and the coreid bug, certain studies were undertaken.

Oryctes monoceros and its control

Investigations were carried out more on the biological control of the beetle, using the virus *Baculovirus oryctes* Huger and the fungus - *Metarrhizium anisopliae* (Metch.) Sor. with bias on the former. The virus has been known to be pathogenic to other rhinoceros beetle species including *O. monoceros* (Julia *et al.*, 1976). Unfortunately, a survey in Tanzania on *Baculovirus* in the natural population of *O. monoceros* and *O. gigas* and or *O. boas* revealed no trace of this virus. Thus, introduction was imperative. In the case of *M. anisopliae*, however, strains of the fungus do occur naturally in all immature stages and adults (Seguni *et al.*, 1987).

Studies with Baculovirus oryctes

Three isolates of *B. oryctes* from *O. rhinoceros* introduced from Western Samoa (SV), the Philippines (PV) and the Seychelles (SEY) were experimented upon to investigate their respective virulence on *O. monoceros* beetle in Tanzania, using a standard dose of 10^{-4} g virus - diseased midgut in the test of infectivity. Infection rates of 60-80% were usually obtained with PV isolates. In some cases, infection reached as high as 90 per cent. SEY isolates gave consistently low infection rates of 16-40% on *O. monoceros* from Tanga and Zanzibar, while the same isolate produced 90 per cent infection on *O. monoceros* from the Seychelles (Paul *et al.*, 1983), suggesting a possible genetic variation of the two *O. monoceros* populations. It was concluded, therefore, that *O. monoceros* from Tanzania is more resistant to the virus *B. oryctes* than *O. Monoceros* from the Seychelles and *O. rhinoceros*.

After some experiments, the FD virus strain was suggested for release (Paul *et al.*, 1983). However, in later transmission experiments (Purrini *et al.*, 1984) a rather low infection rate of 40-60 per cent was consistently observed. Thus, prompting further experimentation includring use of mixed strains, i. e. PV+SV, SEY+SV, PV+SEY, and SV+PV+SEY. The PN+SV combination was found, to be highly pathogenic with 80-100 per cent infection rates, These mixed strains were, therefore, released. Possibly, this enhanced infectivity of the mixed strains can be due to some synergistic effects of the two strains in combination. No differences were detected by electron microscopy from the appearance of the viral rods belonging to PV+SV, PV, SV and SEY.

The culminating aspect on the virus study was the field release of virus infected abult beetles by transmission of the infective virus to healthy beetle populations mainly during the copulation process. Monitoring of the release showed an establishment of the virus in nature. The trap and field-collected adults showed symptoms in the nuclei of their gut cells which were undoubtedly due to virus infection. The infection rate averaged 31.0 and 22.3 per cent from all specimens diagnosed for virus in Vuo - Gezani and Magawa, the two release areas, respectively. Presence of the virus in the field was also demonstrated by biological assay experiments using suspected virus-infected guts from beetles collected in the release areas. Such guts were macerated, prepared as inoculum and tested on healthy beetles, some of which developed symptoms of virus infection after four weeks of incubation. Specimens were also prepared for electron microscopy and the micrographs of a specimen from Vuo-Gezani area showed virus development in the initial stage. However, in many cases where a specimen was diagnosed as positive, the full virus symptoms were not yet developed. Many nuclei of beetles diagnosed as positive were clearly hypertrophies, accompanied by initial disintegration of chromatin. In some cases, the nuclei showed abnormal hyperthropy without any other accompanying symptoms. This weak expression of the virus symptoms might be expected for the following reasons (Seguni *et al.*, 1987): 1) resistance of *O. monoceros* to the virus; 2) possible lower dose of the virus taken by the insect through accidental infection - perhaps much lower than the inoculation dose in the laboratory; 3) diagnosis of perhaps relatively healthy specimens, since beetles which contracted higher dose of the virus might had been "so sick" that trap collection was no longer effective; and 4) insufficient sensitivity of the diagnostic method to detect weaker infections. The effect of the virus on the sex ratio of *O. monoceros* in the field was not observed, probably due to low infection percentages of 31.0 per cent in Vuo-Gezani and 22.3 per cent in Magawa. In *O. rhinoceros* Zelzany (1979) noted a female-dominated field population ratio where the virus was successfully established. This was due to higher percentage of virus transmission from females to males than *vice versa*. Similar phenomenon was observed in Seychelles (Lomer, 1986) on *O. monoceros*, but under field infection percentages of up to 50%.

Post-release figures from damage surveys in Vuo-Gezani and Magawa showed a decline in the damage level.

From these studies, the following conclusions were drawn: 1) *B. oryctes* is infecting *O. monoceros*, although the effects of the virus are reduced compared to effects on *O. rhinoceros*. The almost sterilizing effect of the virus infection on *O. rhinoceros* was not observed on *O. monoceros* 2) the virus was transmitted from diseased to healthy adults of *O. monoceros* 3) a mixed infection of virus from the Philippines and from Western Samoa produced better infection rates on *O. monoceros* than infection with any single strain; 4) the virus released in the *O. monoceros* population in Vuo-Gezani and Magawa has become established in both areas; 5) the virus was still present even after two years of release in Vuo-Gezani and after 16 months in Magawa 6) the percentage virus infection of beetles collected in attractant traps was about 30 per cent 7) virus symptoms in the beetles were weak and difficult to diagnose with light microscopy; and 8) damage caused by the beetles at the release areas was reduced compared to the damage prior to the release, but the differences were not spectacular to draw final conclusions. Therefore, the observations will be continued for another year. Experiments on virus transmission among adults under field conditions, effect of virus infection on the reproduction of the beetles and effect of virus infection on the flight activity should be conducted before the release programme is extended to other areas of high beetle population.

Studies on Metarrhizium anisopliae

The green muscardine fungus - *Metarrhizium anisopliae* (Metch.) Sor. was first recorded as a pathogen of *O. rhinoceros* in Samoa (Friederichs, 1913). Since then, several attempts were made to use this fungus as a microbial insecticide in various parts of the world with varying degrees of success. This fungus occur in nature, although at subdued levels.

In Tanzania,very few naturally infected insects were found. Perhaps the fungus is in such a low level in the natural environment that epizootics do not occur (Allard, 1984).Nonetheless, from the screened infected larvae and adults a highly pathogenic long-spored strain designated as M 30 (11.5 microns) was isolated in October 1982 from a locally infected *O. monoceros* adult. The fungus was multiplied on dextrose agar medium and grown saprophytically on sorghum. This isolate was mass produced in Zanzibar using maize. It was noted that in the mass production process the contamination of *Penicillium* sp. inhibited production of *Metarrhizium* spores. Under laboratory conditions, pathogenicity tests with the fungus gave very promising results, possibly because of controlled environmental conditions which promote growth of the fungus. Infected larvae developed a creamy colour, stopped feeding and became moribund. The body hardened due to ramification of the hyphae throughout the body cavity. Soon the insect died and white hyphae appeared on the integument. About two days later, characteristic green spores appeared on the integument. Pupae infected during the third instar larval stage took about 25 days before death.The appendages became deformed and the body shrunk. The body contents hardened and spores appeared between the segments.With adults, spores were observed on the inter-segmental membranes of the leg joints and on the neck and antennae. The whole body cavity became filled with hyphae.

The encouraging results in the laboratory warranted field release of the fungus. In the field, however, the results did not substantiate the findings in the laboratory. Also, a continuous maintenance of a laboratory to mass produce the fungus for field release had to be sustained, thereby making it an uneconomical control agent. Foremost, however, the natural climatic conditions in coconut growing areas of Tanzania may not be conducive to promote growth and maintenance of an adequate amount of inoculum due to dry conditions and higher temperatures. It is known that infection in nature is favoured by high humidity, relatively low temperatures and of course high quantity of inoculum potential.

Other studies related to O. monoceros

Investigations carried out from December 1983 to July 1984 on disease agents of the natural population of *O. monoceros* in Tanzania revealed the presence of different parasites belonging to bacteria, rickettsia - like organisms, fungi, protozoa and *Helicosporidium* sp. (Purrini, 1984). Fungi, other than *M. anisopliae*, probably belonged to the genera *Aspergillus, Beauveria* and *Entomophthora*. Field infection was low, approximately 1-2 per cent. The bacteria found to infect larvae and adults of *O. monoceros* belong to potential disease agents which cause infection, usually when the host is weakened or under stress (*Bacillus sphaericus, B. cereus, Clostridium* sp, *Pseudomonas* sp. and *Achromobacter* sp. The infection rate of L 3 - larvae during mass rearing ranged from 10 - 60 per cent and adults 0-10 per cent. Some micro - organisms similar to *Rickettsia* were also found to infect L 3 - larvae in wild palms. On the protozoan parasite, a neogregarine - *Ophryocystis oryctes* Purrini, two microsporidians - *Pleistophora tanzaniae* Purrini and *Oryctosphora neddenriepi* Purrini were found to infect *O. monoceros. Helicosporidium* sp., a parasite infecting only larvae of *O. monoceros*, was found on six specimens collected from wild palms.

Other control measure studies against *O. monoceros* included mechanical control, through field sanitation and destruction of breeding sites such as burning and stacking of logs to facilitate faster decomposition-indexing and checking for beetles in the process and direct hooking of beetles in palms and chemical control through insecticide and repellents applied directly to the palms. It was found that Aldrin afforded limited protection. Insect repellent trials using neem extracts-sand mixture gave very little or no effect.

Pseudotheraptus wayi and its control

The coreid bug-*Pseudotheraptus wayi* Brown is undoubtedly a very serious pest in Tanzania, economic importance of which was underestimated, initially. Devastating damage was noted in the young coconut seed garden at Selem in Zanzibar. In Zanzibar, Way (1953) showed several folds of yield increases following insecticidal treatments. In 1954 Vanderplank observed similar results, the annual yield increase due to coreid bug control was from 4.64 nuts/palm to 58, although *P. wayi* was only partially controlled (Keyserlingk, 1985). Vanderplank (1959) recorded an increase in yield from 8.5 nuts/palm to 78.8 nuts/palm in 1955, following successful establishment of colonies of the predatory ant *Oecophylla longinoda* Latreille. It was concluded in 1959/60 in Zanzibar that about 67% of the potential crop was lost due to the bug. More recent data for Zanzibar (Way, 1983) showed yields on the five oldest spadices as 33 nuts/palm in *O. longinoda*-colonized palms compared with about 14 nuts among palms colonised by other ants. The corresponding figures from Tanga region were 26 and 19 the figures for Bagamoyo-being 23 and 12. This does not account for the decreased yield on the economic products of damaged nuts which developed to maturity. The proportion of damaged nuts in *O. longinoda*-colonised palms ranged from 1 to 10 per cent in different localities and in palms occupied by other ants, the damaged nuts were 67% in Zanzibar, 51% in Tanga and 54% in Bagamoyo (Way, 1983).

Chemical control of P. wayi

The impact of *P. wayi* damage was best appreciated with the hybrid seed production at the seed garden in Zanzibar. To control the bug, Lindane 20% EC (gamma BHC) was sprayed to the opening inflorescences and the developing bunches of about 4 months age and younger at concentrations 0.26% and above of the commercial product. Initially, spraying was given at fortnightly intervals which was later extended to 3-4 weeks, depending upon the degree of damage observed in the youngest developing bunches. In the 1950's dusting with 0.4% gamma BHC was found to be effective against the bug (Way, 1953). It was evident that without insecticide treatment, no yield could be realised in the seed garden, even up to the present.

In 1986, Dimethoate 40% EC (253 g ai/ha), Dicarzol 50 WP (formethanate at 500 g ai/ha) and Thiodan 35% EC (endosulfan at 221 g ai/ha) were tested in the seed garden. Thiodan was the most effective and it showed good activity against the coconut mite *(Aceria guerreronis)* and was not harmful to the weaver ant, *O. longinoda* (Oswald, 1988). Other insecticides recommended at present are Dimethoate and Lindane at commercially recommended rates, but both insecticides adversely affected the predatory ant species.

Biological control of P. wayi

Biological control of *P. wayi* is possible using the ant species, *Oecophylla longinoda* but successful establishment, maintenance, sustained growth and further colonising activity of additional palms have not been achieved. Further search for natural enemies of *P. wayi* is in progress. For instance, one strepsipteran parasite of adult bugs and at least one species of egg parasitoid were noted. With *O. longinoda*, it was observed that the presence of competitor ants *(Pheidole megacephala* and *Anoplolepis* sp) hinders its establishment. A Study was undertaken (Oswald, 1988) to suppress *P. magacephala* in order to promote *O. longinoda* establishment using the fire ant bait containing 0.88% ai Hydramethylon dissolved in refined soyabean oil co-solvent (AMDRO) impregnated unto pregelled defatted corn grits (Harlan, 1981 and Samway, 1985). This gave good control against *P. megacephala*. Ground application also killed the colonies of the competitor ant and did not affect *O. longinoda*. Thus, AMDRO application can be considered to suppress *P. megacephala* in order to promote establishment of *O. longinoda*. After the control of *P. megacephala*, *O. longinoda* substantially colonised trees formerly occupied only by the competitor ant.

Farming Systems Research

Farming systems research (FSR) is a recently added component to NCDP activities. It will combine agronomic, economic and sociological research aspects in on-farm trials to investigate the applicability and appropriateness of generated technology for the entire coconut farming enterprise, with particular emphasis on small holders. Current and improved husbandry methods as well as different varieties will be compared and farmer responses monitored and evaluated. The focal point of interest is to gain insight relevant for coconut production, with research emphasis on the interactions between the palms and other elements of the farm organisation such as cropping pattern, intercropping, animal husbandry and the competition for available farm resources. Such interactions will be analysed in the context of natural and socio-environmental aspects.

Specifically, the objectives of the FSR programme are : 1) to describe the major farming systems in the coconut growing areas of Tanzania and understand their mode of operation; 2) to identify problems and constraints that hamper agricultural production; 3) to develop background information for planning and policy making; 4) to provide the basis for setting of research priorities; and 5) to train personnel in FSR methodologies. To achieve these objectives, the programme must establish close cooperation with active organisations and other on-going programmes in the field of agricultural research and extension. The FSR programme will consist of two major components : 1) socio-economic farm management surveys; and 2) adaptive on-farm experiments.

The purpose of the surveys is of a diagnostic nature, i. e. to identify the problems and constraints. The results need not be statistically representative for a certain area or a certain group of farmers. It may be revealing to study a small group of farm households intensively than undertaking widely encompassing cross-sectional studies. The selected farmers should be typical small holders, who depend on agriculture as their main source of livelihood.

The main purpose of on-farm experiments is to test new technologies under farmer conditions and see whether they are adapted not only to bio-physical conditions but also to farmer's goals and possibilities. On-farm research, however, is an adaption process of technologies going through various cycles. In this case, the overriding question in on-farm experimentation is how the co-existence of coconut with other perennial or annual crops can be optimised according to farmer's, goals and needs.

Utilisation, Processing and Marketing

Coconut utilisation in Tanzania hinges mainly on the supply of edible oil. Additional economic utilisation of the nut and other useful parts of the tree are not sufficiently developed yet. About three-quarters of total production remains in the producing areas, where it serves as the major source of vegetable oil. The second largest product destination is the urban consumer, using up about one-fifth of the total fresh nut supply. The share destined to industrial processing of nuts into copra and oil is less than 10%.

Statistical information on vegetable oil supply and demand is scarce. Coconut provides about 40% of the national vegetable oil requirement of Tanzania. It will continue to play a prominent role as the most important single source of vegetable oil. Unlike cotton seed, soyabean, and other potential competitors, coconut can be processed easily into oil or coconut milk of high oil content at household level. In Zanzibar, oil extraction efficiency by home processing was only about 30% below industrial processing standards and may be comparable to the present efficiency of copra - making and industrial oil milling in the Isles.

Zanzibar has maintained a separate stand in coconut marketing. The main aim of the government is to protect the local consumers. Copra prices were fixed and remained constant since the past few years. Recently, these prices were reviewed for taking a decision on an upward adjustment. Trade of freshnut is left to the private sector within the Islands. During the recent years, the Zanzibar State Trading Corporation (ZSTC) and the MALD's Agricultural Corporation were also allowed to sell limited quantities of freshnuts to the mainland. ZSTC is the sole purchasing and sales agent for copra and also holds monoply in the domestic and export trade of coconut oil.

Freshnut prices on both Mainland and Zanzibar, increased over the past years. Now, the relative price of freshnuts assures an advantage of about 300% over the price of copra to an average producer in the mainland. In Zanzibar, freshnut and copra prices were about at parity levels until about 1984/85. Recently, the relative position of copra price was weakened, especially with freshnut trade possibilities to the mainland.

Market projections on the vegetable oil sector may vary widely. But it is recognised that the present demand is far from being satisfied by local supply. Import of vegetable oil by private sectors was allowed during the past five years. However, the foreign exchange required for these imports is not obtained from the central bank. This inflated retail prices for imported vegetable oil as traders budget high "opportunity costs" for foreign exchange. Increase in population would further distort the present vegetable oil supply and demand relationship. At a population growth of 3% p. a. and a constant market share of coconuts, production would have to more than double until 2010, only to keep pace with the present supply pattern (NCDP, 1987). Any growth in per capita income will lead to a correspondingly higher oil demand. Thus, the absorptive capacity of the local vegetable oil market is highly conducive for an expanded coconut production programme.

In the International scene, even under an aggressive coconut production promotion campaign, the coconut industry of Tanzania cannot be expected to register any significant economic trade influence in the medium term. To take full advantage of the coconut industry in the long run, product utilisation, processing and marketing must be dealt with equal vigour and enthusiasm as any other coconut promotion campaign.

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