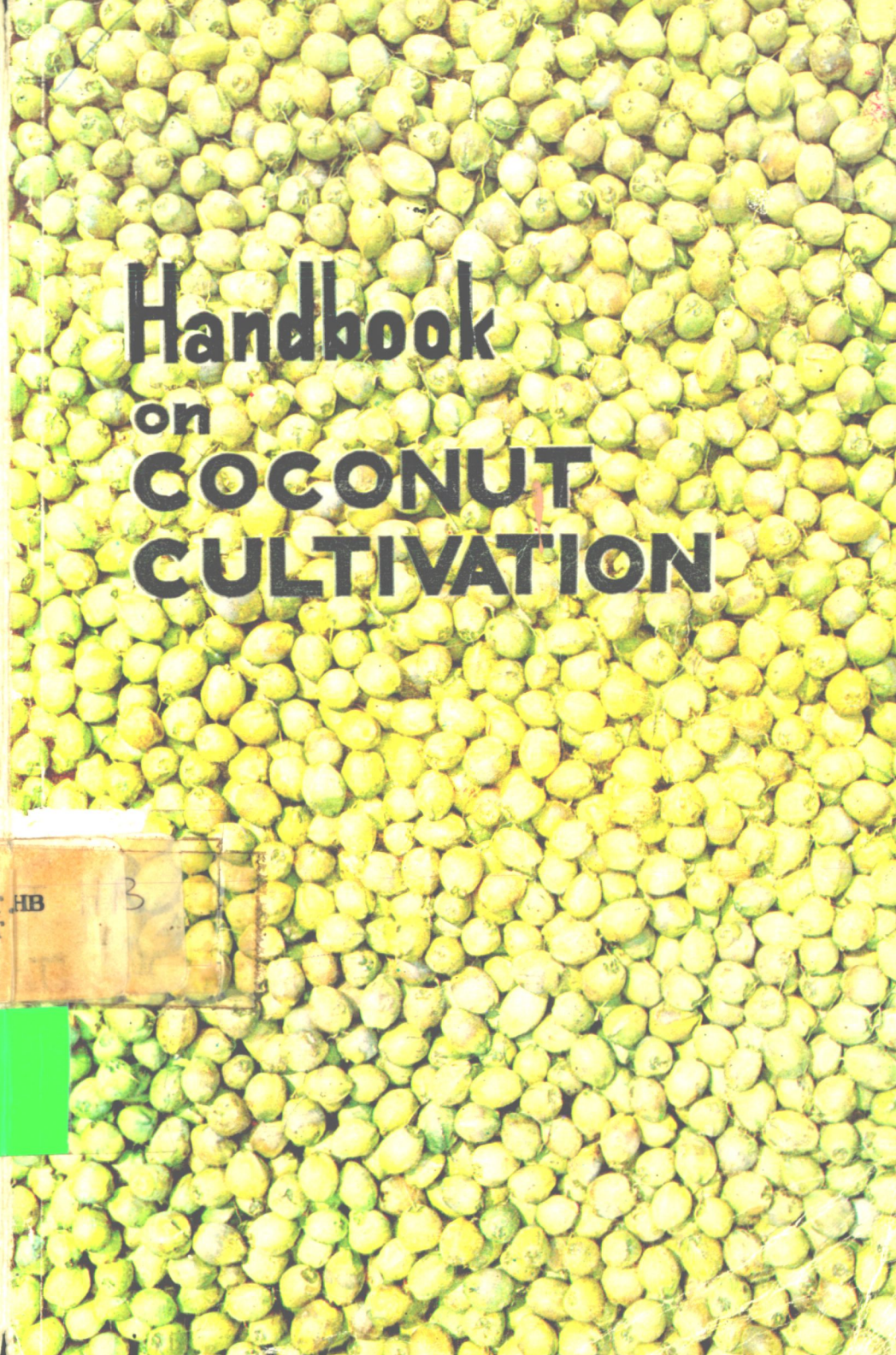


Handbook on COCONUT CULTIVATION

CEYLON PRINTERS LIMITED, COLOMBO 2

HANDBOOK ON COCONUT CULTIVATION

Edited by

U. PETHIYAGODA

DIRECTOR

COCONUT RESEARCH INSTITUTE OF SRI LANKA

LUNUWILA

FOREWORD

This "Handbook on Coconut Cultivation" is being issued to mark the completion of fifty years of operation of the Coconut Research Institute. The Institute is perhaps the oldest of its kind devoted to this single remarkable crop. It stands in testimony to those who agitated and strove to establish it, the Boards that have controlled and guided its destinies, the scientists who have toiled and laboured, often under intolerable difficulties, to build and nourish it and that variety of participants in the industry who have directly and indirectly helped to sustain it.

Today, the Institute employs over a dozen post-graduate qualified researchers, approximately double that number of graduate officers and more than a hundred technical officers in the laboratories and fields. It began small but has today built itself into an Institute of national and international respect. At least six of its scientists serve or have served in International Organizations.

It is fitting that the present day occupants of the key positions in the Institute should have subscribed and co-operated in the production, compilation and editing of this, as one record of their services and those of their official forbears to the coconut industry of Sri Lanka.

This Handbook is not a textbook and so lays no claim to being comprehensive. It is not a scientific dissertation and so does not seek to debate contentious technical issues, nor is it a prescription for all ills that face the industry's future. It has of necessity, a distinct Sri Lankan flavour but is yet, hopefully, of general interest to the coconut world. It is not pretentious in seeking to blow the trumpet of Sri Lankan workers, yet it gives credit where credit seems due. Above all, it is a token of appreciation of the industry's support to the institute and a modest re-assurance that the Institute has unquestionably earned its keep.

A conscious attempt has been made to avoid technical jargon; yet the Handbook gives some of the background to enable an appreciation of the reasons for, and value of, the subjects that have been matter for inquiry by the Institute. It is also hoped that the many areas where large questions would seem to remain unanswered will attract the attention and effort on the part of readers within and outside the Institute, to a renewed vigour in filling in the gaps.

Publication of this book was delayed due to an unavoidable matter.

This Handbook is primarily directed towards the grower and thus in a sense is basically agronomic in approach. It is hoped before long, to bring out a companion issue — a Handbook on coconut processing, and in the fullness of time, perhaps another to complete the trilogy — A guide to Economic issues.

It is our fervent hope that the present issue will lead to an appreciation of the contribution that the Coconut Research Institute of Sri Lanka has made towards the well-being of an industry through whose faith and confidence, support and assistance, goodwill and co-operation, kindness and understanding, the Institute faces with confidence and expectation the next fifty years in which it hopes an even finer record of service — not in denigration but in a spirit of veneration of the pioneers — will be established.

Dr. U. PETHIYAGODA
Director
Coconut Research Institute of Sri Lanka

15th December, 1980.

CONTENTS

CREDITS

Many have contributed in manifold ways towards the production of this volume. However, it would be fitting to mention by name, the following members of the staff for a larger than average involvement in its production:—

U. Pethiyagoda	—	*Director*
V. Abeywardena	—	*Biometrician*
P. Loganathan	—	*Soil Chemist*
R. Mahindapala	—	*Crop Protection Officer*
B. H. Rohitha	—	*Research Officer*
S. M. P. Subasinghe	—	*Extension Officer*

P. A. Henry Nimal

Acting Publications / Publicity Officer

SECTION I

INTRODUCTION

THE PLACE OF COCONUT IN THE WORLD AND ITS POSITION IN SRI LANKA

CHAPTER 1

INTRODUCTION

The coconut palm is one of the most useful and important trees in the world and it has had a long association with human history. In scientific nomenclature, the coconut palm is named as *Cocos nucifera*.

World's total coconut extent is over 5,923,000 ha. Ninety percent of this extent acreage of coconut lies in the zone between 20°N and 20°S latitude where the six primary coconut producing countries are situated. They are the Philippines, India, Indonesia, Sri Lanka, South Sea Islands and Malaysia.

The coconut tree yields more products of use to mankind than any other tree known to man. The variety of products derived from the coconut palms throughout the world is practically boundless. The nut of the coconut palm could truly be counted among the most important fruits of the world. The tender nut supplies a refreshing beverage and the raw kernel is an important article of food in all coconut growing countries. A number of commodities are derived from the nut which enter international commodity markets. The dried kernel, copra, is a major source of oil. Coconut oil is an important and one of the oldest items used in the manufacture of soaps, other cosmetics and in margarine. Poonac or "pressed cake" which is the meal after oil expression is a valuable livestock feed. Desiccated coconut is used widely in bakery and confectionary trades the world over.

The husk of the nut provides a high quality hard fibre which is used in numerous industries. Locally, fibre provides the valuable raw material in spinning coir yarn and in the manufacture of coir ropes, cordage, brooms, woven carpets and many other utility items.

The hard shell is mainly used locally as a fuel but there is a heavy demand for carbonised coconut shells in overseas markets. Some of this shell-charcoal is converted into activated charcoal which has important industrial uses as a deoderant and in decolorising and combating air and water pollution.

Finely ground coconut shell is used as a filler in the manufacture of some thermosplastics — especially the early plastics manufactured.

The timber from the trunk is utilised in house construction, furniture manufacture, turning out curios and potentially in particle boards.

There is a high potential for manufacturing activated charcoal using coconut-trunk-charcoal once a suitable technology is evolved.

Plaited coconut leaves provide lasting and inexpensive thatching material. The juice obtained by tapping the inflorescences is rich in sugars. This may be converted into jaggery, treacle or sugar, or be fermented to yield alcohol and subsequently vinegar.

The value of coconut as an economic crop is obvious. In Sri Lanka, coconut is the major tree crop grown in over 466000 ha of combined. Its extent equals that of the other two major crops—tea and rubber. In contrast to the other two major plantations crops in Sri Lanka, as much as three-quarters of the coconuts currently produced are consumed within the country. With the balance that is exported, coconut products earn the third highest foreign income among the plantation crops. Coconut being mostly a small holders' crop in the country its development and improvement for better returns is an urgent economic, social and political necessity for Sri Lanka.

CHAPTER 2

THE PLACE OF COCONUT IN THE WORLD AND ITS POSITION IN SRI LANKA

Coconut is known to be the most valuable palm in the world as it yields so many products of use to mankind. Coconut comprises an important part of the diet in Sri Lanka in addition to being a very important source of export earnings. A total of over eight million ha of land has been used in the cultivation of coconuts in the world. The world's total production is about 35 million metric tons of coconuts a year and 80 per cent of this comes from the Asiatic region. Philippines rank the highest amongst the world's coconut producers.

Coconut oil remains the most important product of the coconut palm finding numerous uses worldwide. The world production of copra, the precursor of coconut oil, is at present in the region of 4.8 million metric tons per year.

Coconut growing regions may be grouped into six main coconut producing areas, viz. Asia, Oceania, West Indies, Central and South America, East Africa and West Africa. The Philippines, Indonesia, India, Sri Lanka, Thailand and Malaysia are among the most important producers of coconut in the world. (See Table 1). Some major coconut producing countries have formed a united body (Asian Pacific Coconut Community, the APCC) to study the common interests in the development of coconut industry in their countries.

The area under coconut in the world has been increasing over the past years and according to more recent information, since 1971 over 40 per cent increase in the world's total coconut area is observed (c.f. Table 2). During this period Philippines have increased their coconut area by over 80 per cent, while a 100 per cent increase is seen in Indonesia and Western Samoa. Thailand has shown a 120 per cent increase in the area under coconut during this period.

While the demand for coconuts and coconut products has been steadily increasing in the world, the general world trend in coconut production has been decreasing since 1976. Table 3

indicates the world coconut production by the main coconut growing areas during 1971-1979. This declining trend has been attributed mainly to the adverse weather conditions such as drought and typhoons that have prevailed during that time.

Coconut products are imported by many industrialized countries. Many countries import coconut oil as a finished product while certain other countries purchase copra which would also produce, an animal feed as a by product, in addition to coconut oil. Other important coconut products of worldwide economic importance are, desiccated coconut, which is widely used in confectionary and cocoünt fibre, a high grade natural hard fibre which finds numerous uses.

Among the countries that consume coconut products, the USA the USSR and the European Economic Community (EEC) appear to be important as major importers (Table 4).

Coconut Industry in Sri Lanka

Coconut industry occupies a pre-eminent position in the Sri Lanka's agriculture, that it is only second to lowland rice in land use. While 31.3% of the total cultivable area is cultivated to lowland rice, coconut extends over 21.7% of the nation's agricultural land (Table 5). It contributes substantially, to the country's Gross Domestic Product (GDP), Foreign exchange and Government Revenue, further it offers substantial socio-economic benefits, by way of direct employment to an estimated population of 0.15m, while about 3-3.5% of the country's population depends upon the crop for their living. The Census of Agriculture 1973, estimated the Sri Lanka's coconut area at 45,142 ha, of which, over 90% was managed by the small-holders having less than 8.1 ha (20 acres). The distribution of small-holdings and estates in the coconut growing districts of Sri Lanka is given in Table 6.

Nut Production and Pattern of Utilization

The coconuts are grown exclusively for nut production in Sri Lanka. Only a minor proportion is being tapped for toddy. The annual nut production is estimated based on the export and domestic consumption (Socio-economic Survey 1970) and has been in the range of 2000-3000 m nuts in 1970's. It has recorded its historical peak production of 3148 nuts in 1964 and maintained an even keel around 2500 m nuts upto 1971. In 1973 its recent peak production of 3073 nuts was indicated. However, a sharp drop in production was recorded in 1973. This declining trend has been the result of several attributes, but mainly to the adverse weather conditions and reduced fertilizer applications.

Table 1. Estimated world area of coconut palms (1971) (1,000 ha)

Asia		
Philippines	1800	
Indonesia	1200	
India	978	
Bangladesh	18	
Sri Lanka	466	
Burma	4	
W. Malaysia	200	
Sabah	55	
Sarawak	17	
Thailand	165	
Vietnam	31	4,934
Papua and New Guinea	150	
W. Irien	10	160
Oceania		
Fiji	76	
Solomon Islands	26	
Gilbert and Ellico Is.	12	
Tonga	20	
New Hebrides	80	
French Polynesia	50	
US Trust Territory	29	
E. Samoa (US)	3	
Western Samoa	20	
(Others not estimated)		316
		5,410
		539
Total		5,949

West Indies		
Trinidad and Tobago	18	
Jamaica	22	
Bahamas	2	
St. Vincent	3	
Grenada	2	
St. Lucia	5	
Dominica	2	
Puerto Rico	4	
Dominican Republic	5	63
Central and S. America		
Mexico	100	
Panama	13	
Brit. Honduras	2	
Brazil	80	
Peru	2	
Guyana	14	
Surinam	2	
Venezuela	19	232
East Africa		
Mozambique	70	
Zanzibar	16	
Pemba	5	
Tanzania (Tanganyika only)	20	
Kenya	20	
Seychelles	12	
Mauritius (including dependencies and BIO Territories)	7	
Madagas. and Comoro Is	15	165
West Africa		
Dahomey	25	
Ivory Coast (possibly)	25	
Togo	5	
Ghana	14	
Nigeria	10	79
		539

Source, Child (1974)

Table 2. Area under cultivation and production of coconut in APCC Countries, 1978

Country	Area		Production of Coconut		Production of Copra	
	(1000 Ha.)	% share	(million nuts).	% share	(1000 MT	% share
India	1080	12.9	5845	18.9	350	8.9
Indonesia	2435	29.1	7265	23.4	900	23.0
Malaysia	325	3.9	894	2.9	160	4.1
F.H.G.	252	3.0	798	2.6	143	3.7
Philippines	3317	39.6	12882	41.6	2133	54.5
Sri Lanka	466	5.5	2258	7.3	131	3.4
Thailand	400	4.8	550	1.8	40	1.0
T. T. P. I.	30	0.3	75	0.2	11	0.3
Solomon Islands	34	0.4	185	0.6	28	0.7
Western Samoa	40	0.5	218	0.7	14	0.4
Total	8379	100.0	30970	100.0	3910	100.0

Source, APCC (1979)

Table 3. *World coconut production by main areas (thousand metric tons 1971 – 73 average and 1974 to 1979*

Countries	*1971 – 73 average*	*1974*	*1975*	*1976*	*1977*	*1978*	*1979 prelim.*
Asia	23936	24642	26676	29587	28090	28564	26990
of which : Philippines	8183	8376	9903F	12950F	11587F	11661F	10460
Indonesia	6567	8279	8352*	8473*	8779*	8900F	9370
Sri Lanka	1903	1553	1965	1771	1384	1520*	1560
India	4451	4400	4331	4284	4260	4370	4370
Malaysia	968	875*	1053*	1049*	1021*	1034F	1050
Oceania	1994	2117	2150	2176	2260	2259	2300
Latin America	2114	2104	2046	2123	2123	2236	2240
Africa	1502	1515	1505	1485	1607	1580	1520
World total	51618	53861	57981	63898	61111	62124	59860

* Estimated value

F FAO value

Source, FAO After Oleagineux, 35(ii).

Table 4. Imports of copra and coconut oil by selected countries (1000MT) during 1979 and 1980

Countries	*Copra*		*Oil*	
Copra	*1979*	*1980*	*1979*	*1980*
Belgium			19.9	28.5
Denmark	18.3	13.7		
France	18.3	13.7	45.2	28.5
Italy	10.0	10.1	45.0	40.7
Japan	55.7	64.7	47.9	34.6
Netherland... ...	57.8	46.3	53.3	56.0
Spain	4.0	5.7	20.1	19.4
U.S.A.			443.8	403.4
U.S.S.R.			48.0	79.3
West Germany ...	53.9	53.2	142.0	155.7

After cocomunity 11(15)

Table 5. Utilization of cultivable land for agricultural uses

	Extent (ha)	*% per total*
As wedderrized paddy	653168	31.3
Coconuts	451482	21.7
Tea	244099	11.7
Rubber	226599	10.9
Other temporary crops	166242	7.9
Other permanent crops	230958	11.1
Wood and Forest land	42973	2.1
Pastures and Grazing land ...	80344	0.4
Uncropped cultivable land ...	60552	2.9
Total cultivable land	2084107	100.0

Source : Dept. of Census and Statistics ;
Statistical Pocket Book 1980, and
Census of Agriculture 1973.

Table 6. Area of cultivation of coconut managed by the estate owners (with 20 acres) and small holders (with 20 acres) in different districts in Sri Lanka

	Area under coconut	
	Holdings less than 20 acres (8.1 ha) in size	*Holdings over 20 acres in size (Estates)*
Colombo	182194	8993
Kalutara	28301	952
Kandy	19126	3266
Matale	24282	7436
Nuwara Eliya	1034	64
Galle	42159	2784
Matara	39617	774
Hambantota	58788	1326
Jaffna	19716	859
Mannar	3467	—
Vavuniya	4898	606
Batticaloa	4906	595
Amparai	3159	701
Trincomalee	2339	—
Kurunegala	348967	49563
Puttalam	123168	19624
Anuradhapura	14651	274
Polonnaruwa	3141	8
Badulla	5578	101
Moneragala	5750	—
Ratnapura	30236	721
Kegalle	49002	2484
Total	1014479	101131 G. Total
		1115610

(Source : Census of Agri. 1973)

Domestic Consumption and Exports

The country's nut production is basically used in household consumption for culinary purposes (58%) and the balance is converted to either copra or desiccated coconut, while former in turn is further processed to oil before being exported or used for local consumption.

The per capita domestic consumption by way of oil, fresh nuts and industrial uses, amounted to 132.3 nut equivalents (ne.) in 1970 (Socio-Economic Survey 1969-70). The national domestic consumptions is thus calculated based on the mid year population, and the above datas, shows a steady growth with the increasing population. By 1981 it was estimated at 1946 m ne. whereas in 1970 it was only 1627 m ne. However, the major deficiency in the above estimates is that the changes in the population pyramid is not taken in to account which undoubtedly affect the per capita consumption. Exports, being a residual amount after satisfying the above domestic requirement had been subjected to wide fluctuations. The average annual export volume which was over 1200 m ne. in 1950's through mid 1960's had fallen less than half of this level towards the latter part of 1970's. It has reached a record low of 240 m ne. by 1980. However, the figures for 1981 (402 m) and first half of 1982 (248.6 m) show evidences of recovery.

Exports and Contribution to G.D.P.

Sri Lanka's coconut exports are basically of two categories: kernel products and by-products. All items derived from the kernel including DC, OIL, Copra and also fresh nuts are grouped into kernel products and the rest including fibre, shell products and other by-products constitute the by-products. As an export earner the share of the kernel products exceeds 75% while the by-products appeared to have improved their share during the last 2 decades from 17.4 in late 1960's to 24% in late 70's. The share of the coconut products in the total export earnings of the country has undergone wide fluctuations (7-17%) during the last decade, depending mainly on the size of the overall coconut crop (Table 7) and the relative improvements of the other sectors such as tourism and garment industry in foreign exchange contribution. Similarly, the share of the GDP contributed by the coconut industry has declined over the last three decades from around 10 percent in 1950's to around 5 percent in late 1970's. This suggests that the coconut industry is not growing its output in par with the overall growth of the GDP.

To avert this trend and to safeguard the coconut grower from a possible crisis the Sri Lankan Government has introduced several policy measures to revitalize this important industry. Among those, more emphasis is given to rejuvenate the existing plantation through systematic programme of replanting with improved planting material.

A rehabilitation package is underway, which include the supply of seedlings at subsidized rates, cultivation subsidies, input supply and an extension service to provide necessary technical knowhow.

The coconut palm can tolerate the least amount of grower attention still providing the grower with substantial financial benefits. This remarkable feature of the crop has probably made the grower indifferent towards his management practices and, hence acclaimed its popularity as the 'lazy man's crop'. Nevertheless it is high time for the growers to disregard this traditional belief and to realize that the proper management could bring about two or three-fold increase in nett returns within a short period of time.

Table 7. Coconut Production and Export Earnings from Coconut Products

Year	Production	Exports	Export Value		Export Earnings	
	m. nut equ. (1)	Volume (m ne.)	Rs. million	SDR m	Total export earnings	As a % of GDP (*)
1970	2605	860	290	50	15	2.3
1972	3073	1258	343	51	17	2.3
1974	2353	468	548	68	16	2.4
1976	2766	811	507	52	11	1.8
1978	2443	594	1271	65	10	3.2
1980	2153	239	1234	57	7	2.0
1981	2348	402	1438	64	7	2.3

Source : (1) CRI Estimates (*) at current factor cost

Central Bank — Annual Reports

SDR — Standard Domestic Rupee

GDP — Gross Domestic Product

SECTION II

MORPHOLOGICAL FEATURES

TYPES OF COCONUT

CHAPTER 3

MORPHOLOGICAL FEATURES

Before attempting to grow any crop it is best that the grower knows the morphology and other characteristics of the crop plant. The present chapter is intended to provide a brief outline of the morphology of the coconut palm (*Cocos nucifera.* L) although the general features of the coconut palm are well known. The Order Palmae includes more than 200 genera arranged in families. The coconut is included within the Family Cocoideae which includes ten genera. The genus *Cocos* is considered to have only a single species *Cocos nucifera.* Classifications of coconuts consider the various types (or forms) as distinctions below the species level.

The leaf of the coconut palm is pinnate as in several members of the Order Palmae. When the first few leaves are formed from the seed nut, the pinnae occur fused, but after about the eighth to tenth leaf, the leaves bear expanded leaflets and resemble those of the mature palm. In a young seedling, the stem is inconspicuous and the leaves appear to arise as a rosette — directly from beneath the soil. In about 4 - 5 years after planting, a definite stem or trunk starts to form from the seedling. A frond bears leaflets arranged on either side of the mid-rib the broadened flat base of which encircles the stem to almost half its circumference. In a healthy palm there may be about 30 or more fronds each reaching up to 6 metres in length. When mature an average frond bears over 200 leaflets each of which is 90 - 135 cm long. As the palm ages the length of fronds and the number of leaflets per frond decline. In the centre of the crown, the progressively younger leaves can be distinguished down to the tiny microscopic primodia which are differentiated in the maristem in the central cabbage region. The primodium takes about two and a half years to emerge as a fully expanded frond. There are about thirty leaf primodia distinguishable around the meristem. Figure 1 presents a schematic development pattern for leaves. The leaf when emerged lasts for 20 - 35 months on the tree, the old leaves falling off successively, with the rate depending on plant vigour and the climate.

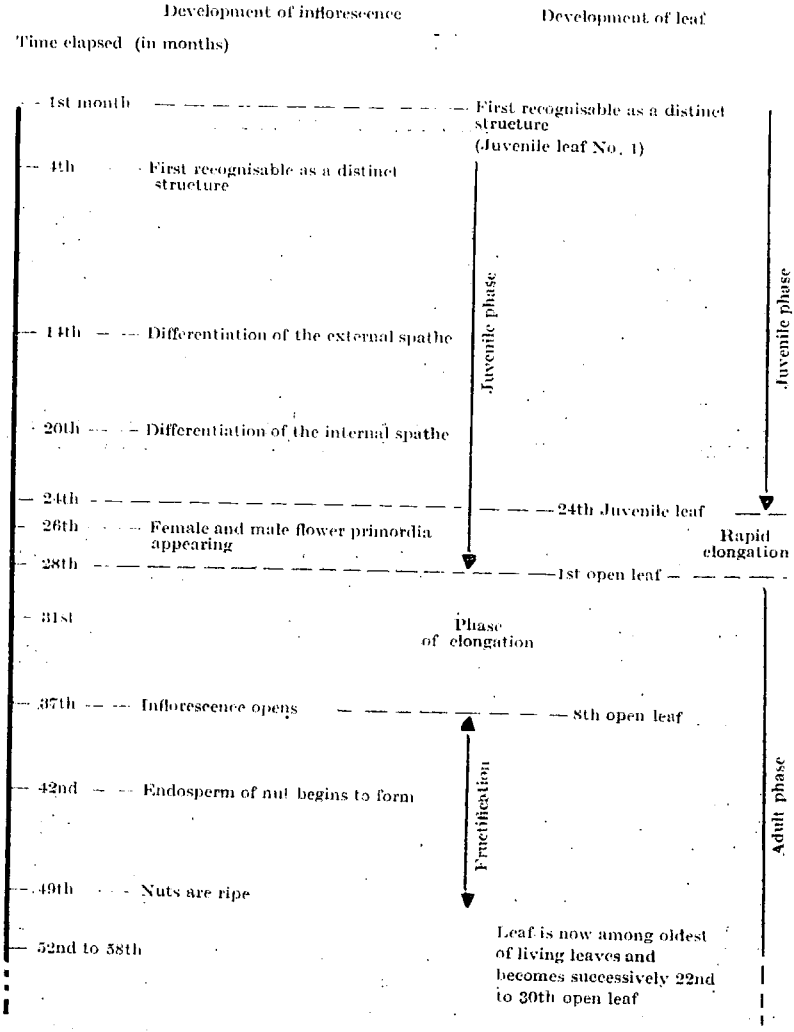


Fig. 1 — Development stages of the inflorescence and the leaf from the primodium (Fremond *et al* 1966).

About 1½ to 3 years leaf production are carried in the crown of a healthy tree.

An average palm produces 12 - 14 fronds per year. Each frond bears an inflorescence in its axil once the palm has reached maturity. A dozen or so fruit bunches bearing fruits at various stages of maturity and ten to twelve unopened spathes occur in the crown at a given time. The leaves occur in five spirals with the sixth leaf roughly below the last emerged leaf and the eleventh leaf roughly below the sixth leaf and so on. The phyllotaxy is expressed as 2/5. The leaf spiral may be right handed or left handed depending upon which side of the cotyledon the second leaf develops from. The leaf spirality is visible in the leaf scars on the trunk.

The Stem

A clear stem begins to grow from about five years after planting. The rate of elongation of the stem is high at the beginning of the growth of the palm and slows down as the tree ages. Under favourable conditions in the early stages, the trunk grows about 1.5 m in an year and the rate falls to about 50 cm per year at about 25 years. At 40 years or over the rate further falls to 10 - 15 cm per year. When fully grown the coconut tree measures about 42 m or more in height.

The differentiation of all parts of the tree originates at the meristem situated as a small region in the centre of the cabbage. Any extensive damage to this tissue would stop the growth, and eventually kills the tree. Abnormal instances of branching of the trunk probably results from a partial damage resulting in a division of the meristem into two or more viable sections. Coconut is a monocotyledonous tree and the vascular bundles which transport water and food occur scattered in the stem as a complex anastomosing system. There is no secondary thickening of the vascular bundles. The trunk is more or less uniform in diameter over its length. The girth of the stem tissue added on is affected by adverse environmental conditions and pests and diseases, resulting in extreme cases, in the condition of "tapering". Drought, waterlogging, severe insect attack are some factors which tend to affect the growing region of the palm in this manner. If the adverse conditions persist, continuous retardation of growth occurs at the crown and the tree will soon lose its crown, as the reduced structural strength of the tapered section will cause it to snap.

The Roots

The roots arise from the enlarged basal part of the stem called the bole. Being a Monocotyledonous tree, there is no tap root, but numerous fibrous adventitious roots are continually produced from the bole along about a 40 cm length on the bole. The bole is much reduced and therefore—not discernible as such in dwarf varieties. The depth of penetration of the roots in sandy soils is greater than in heavy soils. The roots do not easily penetrate compact gravelly subsoils and also do not grow into water or waterlogged soil. Under such conditions a thick mat of roots tend to develop around the bole. This can sometimes occur above ground level. The roots of coconut palm are generally uniformly thick. There are no root hairs but the absorbing area is the one cell thick epidermis which gradually thickens with age. Behind the root cap is the actively growing portion of the root.

The Inflorescence

Typical tall-variety coconut palms come into flower in about the sixth year if water, light and nutrient conditions have been favourable. Dwarf types generally flower in about the fourth year or sometimes even earlier.

Following the emergence of the first flower, inflorescences are continually produced in each successive leaf axil. Some inflorescences may get aborted especially under dry weather conditions. Certain varieties and forms display the consequent seasonality in bearing to a greater degree. It is interesting to note that the inflorescence that has been fertilized and is bearing ripe fruits today has originated and differentiated in the meristem region, as a primodium about four years previously (Fig. 1). Since sensitivity of the generative system is likely to vary with its stage of development (primodium to ripe bunch), any factors that have occurred during this period favourably or adversely influence development, fertilization and maturation, and hence nut production.

The inflorescence is encased in a sheath or spathe which when fully grown splits along the underside and releases the inflorescence. Figure 2 illustrates selected developmental stages of the growing inflorescence. The spathe and the inflorescence are collectively called the "spadix". The inflorescence has many branches on which female and male flowers occur.

Female flowers are typically relatively few in number and are borne on the basal region of the spikelets, while numerous small male flowers occur along the rest of the length of the spikelets. The female flowers can become fertilized by pollen from the palm's own male flowers (self-pollination) or by pollen from male flowers

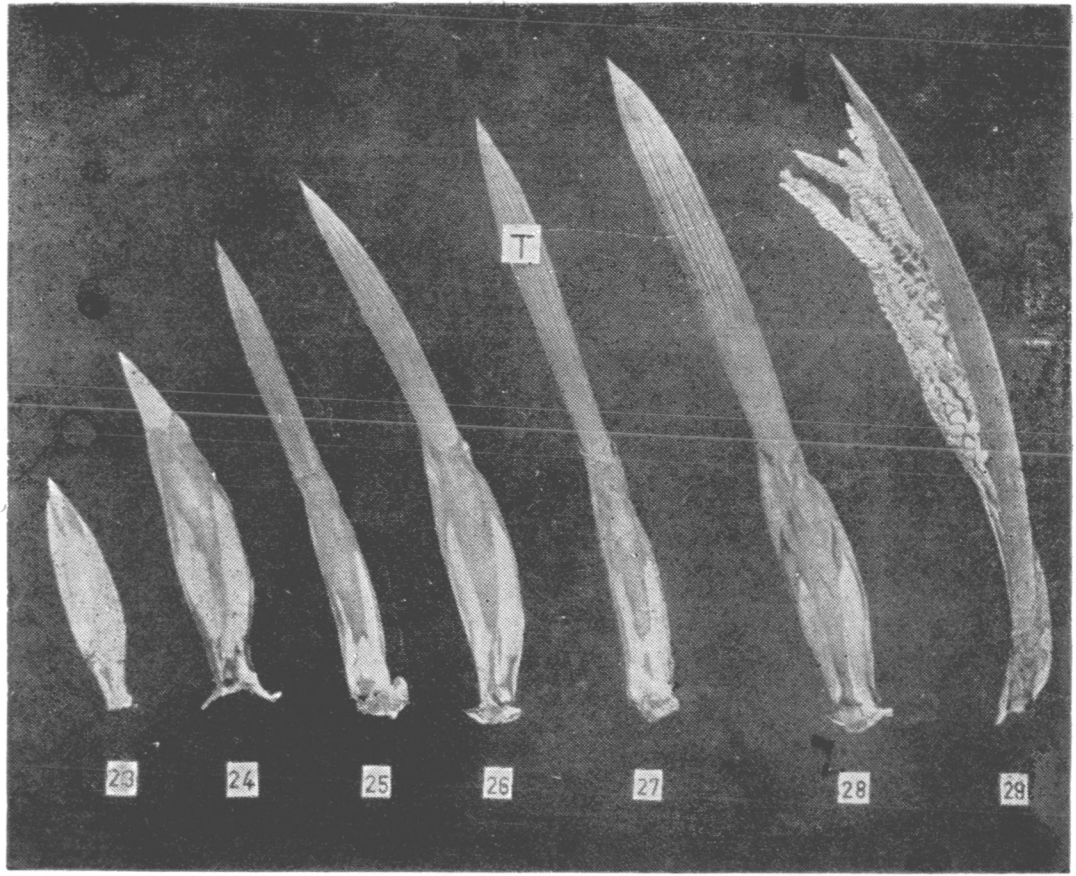


Fig. 2. Selected developmental stages of the growing inflorescence.

on other coconut palms (cross-pollination). A mechanism whereby cross-pollination is favoured operates in coconuts generally. Release of pollen precedes the stage of receptivity of the female flower. This phenomenon is called protandry. Such varieties are referred to as outbreeding while those in which male and female phases coincide are referred to as inbreeding types. In outbreeding coconut inflorescences, male flowers shed their pollen and may have already dropped from the spikelets before the female flowers have become receptive. The stigma which is partly divided into three segments remains protected by the overlapping perianth members until it is receptive, when it protrudes with the receptive surface exposed. At this receptive stage, a secretion of nectar is observed on the nectaries in the receptive region. Female flowers become receptive on the 21 - 23rd day after opening of the spathe, although there may be departures from this rule. Pollination takes place by wind or by insects, predominantly bees, that visit the flowers for nectar and pollen. A given female flower remains receptive for one to two days and the receptive period of the whole inflorescence extends through 2 - 5 days. Environmental factors can influence the pattern and duration of the receptive stage of female flowers.

The button nut enclosed partly in the perianth expands fast and develops a cavity within it which enlarges and gradually fills with liquid. The maximum size of the nut is reached in about six months from pollination. The kernel then begins to thicken and other internal changes such as changing of the constitution of the nut water and the laying of the endosperm takes place from then on, up to about a period of another six months. The development pattern of the nut from the flowering stage to the mature nut is as shown in Fig. 3 The three perianth lobes in the flower persist in the mature fruit.

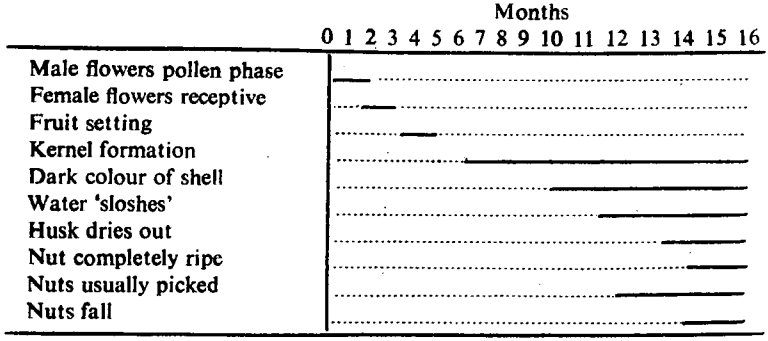


Fig. 3 — Development of the nut from flowering to harvest
(Source adapted from Child (1974)

The fruit of the coconut is botanically referred to as a drupe. The husk comprises an outer smooth epicarp and a fibrous mesocarp. The shell is the endocarp and the kernel is the endosperm which has embedded in it, the embryo at its proximal end. The water in the nut is also part of the endosperm — referred to often as a liquid endosperm.

Germination of the nut

The endocarp or the shell is merked by three outer ridges. At its proximal end, the shell has three depressions commonly known as 'eyes'. One of the eyes (the soft eye) functions as the germ pore in germination while the other two eyes are non-functional. The embryo which develops into the seedling lies just below the soft eye through which the emergence of the prostem takes place. During germination the first roots and the shoot develop from this prostem.

The embryo has a single cotyledon which expands into the 'apple' which progressively enlarges within the nut. The nut water is absorbed and gradually the food reserves in the endosperm are slowly dissolved by the action of enzymes and are fed into the enlarging cotyledon which is now referred to as the haustorium and virtually completely packs the space within the shell. The haustorium is a spongy structure containing about 85 per cent of water but with a considerable content of soluble sugars and a number of enzymes required to mobilise the reserve food stored in the kernel. The haustorium functions as an organ providing the young developing seedling with food materials and gradually degenerates as the seedling becomes self-supporting. The roots generally develop before the stem and leaf. The first external sign of shoot emergence (the "crow's beak stage" is at about the sixteenth week. An early stage of germination is shown in Fig. 6.

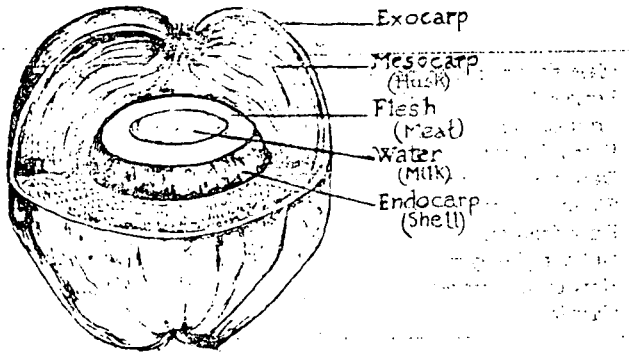


Fig. 4. Parts of a mature nut

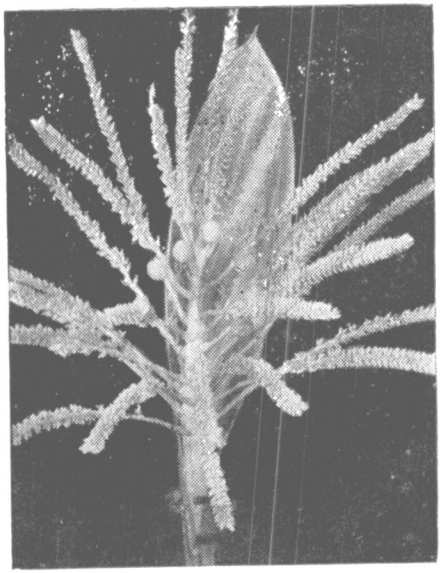


Fig. 5. A fully opened inflorescence

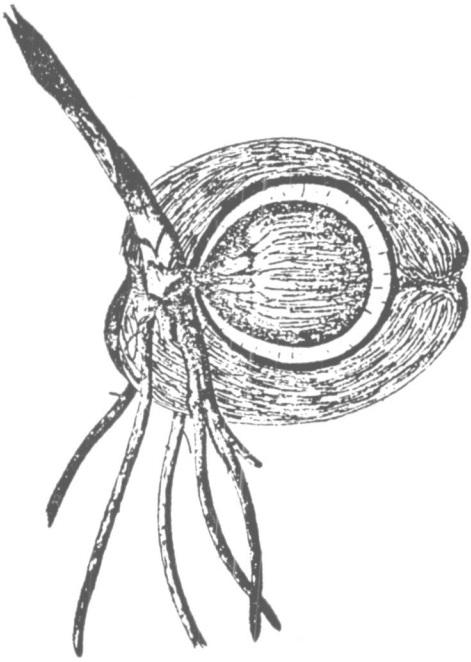


Fig. 6. An early stage of Germination.

CHAPTER 4

TYPES OF COCONUTS

A variety (or strain) generally means a single population having morphological characters recognizably differing from any other population.

A variety generally breeds true to type but can however cross-fertilize with another to produce a hybrid. The species *Cocos nucifera*, due to its global distribution and outbreeding habit, encompasses a number of types varying widely in such characteristics as stature, size, shape and colour of the nut, floral biology, age at first flowering etc. There is consequently much confusion in the recognition and naming of varieties, and different countries have established their own nomenclature of varieties and therefore a tree with similar characters may be named differently in different countries. Estimates of the number of coconut varieties (or types or forms) of coconut vary widely and range from about a dozen to as many as four times that number. Thus, a universal classification of coconut varieties is still lacking although Liyanage (1958) proposed a workable distinction into three principal varieties (*typica*, *nana* and *aurantiaca*) with fourteen "forms" within them.

Varieties of Coconut in Sri Lanka

Several varieties of coconut have existed in Sri Lanka from very early times. As early as in 1856, five coconut varieties were described as Thembili, Navasi, Dwarf, Thembili with large nuts and common tall type. A more recently proposed classification (Liyanage, 1958) of the coconut palms in Sri Lanka is based on morphological characters and breeding behaviour. The following is a brief account of the proposed classification of the varieties and forms of coconut found locally. It is probable that many, if not all of the types existing in other countries in the region can be fitted into these descriptive classes for all practical purposes.

The first distinction into varieties is based on the stature of the plant and on nut colour. This *typica* Nar, is tall in stature with nuts ranging from green through shades of olive colour to brown. *Nana* Griff. are dwarf in stature. Variety *aurantiaca* Liy. is semi-tall with bright orange fruits.

The salient characters of these three varieties are as follows:

(*a*) **Variety typica** *Nar*

This variety is predominantly outbreeding due to the male flowers in a spadix opening earlier than the female flowers. Trees have a broad trunk with an average circumference of about 84 cm and attain a height of about 18 meters. The leaves are long with a mean length of about 5.5 m.* The flowering is late and it takes place normally 6 - 8 years after planting. Flower production is continuous. Nuts are medium to large in size, 4000 - 5200 nuts giving a ton of copra. The copra from this variety is hard and of good quality. These are hardy palms tolerating a wide variation of soil types and climate. Under a favourable environment, the period of economic production is about 60 years.

(* All girth measurements are at 1.52 N above ground and leaf length that of 10 year old palms.)

(*b*) **Variety nana,** *Griff*

This variety is predominantly inbreeding as the male and female phases of the inflorescence everlap. They have a narrow stem with a mean trunk circumference of about 56 cm and they attain a height of about 10.7 m. The leaves are short with a mean length of about 4 metres; flowering takes place early at 3 - 4 years after planting. Flower production is seasonal. The nuts are generally small in size and 9000 - 12000 nuts are normally required to yield a ton of copra. Copra is leathery and of poor quality. Palms of this variety thrive on deep fertile soils in regions with a well distributed rainfall, but they are susceptible to pests and diseases and suffer markedly from drought. The period of economic production of this variety is no more than forty years. Palms belonging to this variety are however not considered an economic proposition, for growing on a plantation scale in Sri Lanka. The variety has proved highly useful in breeding programmes.

(*c*) **Variety Aurantiaca** *Liy.*

Palms of this variety are predominantly inbreeding because the male and female reproductive phases of the inflorescence overlap. The stem is medium sized with a mean girth of about 71 cm and attaining a height of about 12.2 m. The leaves are short with a mean length of about 4.3 m.

The flowering is late and it usually takes place after 6 - 8 years after planting, and is seasonal. The nuts are of medium size; about 8000 nuts giving a ton of copra. The epicarp of the nut is orange in colour. Endosperm is thin and of little value for copra production. These palms thrive in fertile soils with a high water table and in areas with a well distributed rainfall. These palms are however very susceptible to attack by several pests and diseases and they suffer adversely from drought. Economic production period is not more than forty years.

This variety is also prominent in its manifestation of foliar symptoms of nutrient deficiency (especially of magnesium).

1. **Forms within varieties**

The three varieties whose main features have been briefly described can be further sub-divided. These sub-divisions are known as "forms" and their main distinguishing characters are broadly as follows:—

1. **Forms of the Variety Typica Nar**

(*a*) **Form typica:** The nuts are generally oblong. The epicarp (outer skin) of the nut is of different shades of green to reddish brown (copper). The mesocarp (fibrous husk) is a good source of fibre. The endosperm (kernel) is thick and averages about 199 gm dry weight per nut.

(*b*) **Form navasi:** The epicarp is green in colour. Mesocarp of the immature fruit is sweet and edible. The husk of the mature nut is soft and the nut water is insipid.

(*c*) **Form gon thembili:** The epicarp of nut and the mid-rib of the frond is ivory yellow in colour. Water of the tender nut is usually insipid. The nuts are large but the copra out-turn is low. The kernel has a high oil content (69.2%).

(*d*) **Form ran thembili:** The epicarp is green and the mesocarp when cut is pink in colour. The endocarp (shell) is thin. The endosperm is thick and hard. Oil of ran thembili is said to be of medicinal value.

(*e*) **Form pora-pol:** Husked nut is very small and elongated. Endocarp is hard and very thick (about 6 mm). These nuts are used in a type of festive sport ('pora-pol gaseema'—*Sinh.*) occasionally seen in the Southern parts of Sri Lanka.

(*f*) **Form bodiri:**. Palms of this form are prolific bearers. The nuts are however small, requiring about 20,000 to a ton of copra. Each bunch carries 50 - 100 nuts. Oil content of the kernel is high (69.6%).

(*g*) **Form Kamandela:** Nuts are about 1½ times as large as those of the form typica. Only a few nuts are produced per bunch. The distribution of this form is generally restricted to the Southern Province of Sri Lanka.

(*h*) **Form dikiri pol:** Endosperm of this form is soft and is 2 - 3 cm in thickness. Certain portions of the endosperm (or the entire endosperm of certain nuts) are of a buttery consistency and gelatinous. The soft meat of the kernel is considered as a delicacy. This form appears to be closely allied to the Philippine "Macapuno".

2. **Forms of the variety nana. Griff**

(*a*) **Form pumila:** (The Green Dwarf) Inflorescence is yellowish green and the epicarp of the nut is green. Copra is of poor quality. Flowering takes place early generally in 2½ to 4 years from planting.

(*b*) **Form eburnea:** (The Yellow Dwarf) Inflorescence is ivory yellow and the epicarp of the nut is yellow.

(*c*) **Form regia:** (The Red Dwarf) Inflorescence is orange in colour while the epicarp of the nut is apricot red.

The Red and Yellow Dwarfs appear to bear larger nuts than the Green Dwarf found in Sri Lanka. However, there are Green Dwarfs with large nuts known from other countries.

3. **Forms of the variety aurantiaca**

(*a*) **Form thembili:** This form is known by the popular name, King Coconut in Sri Lanka. Upper surface of the leaf mid-rib, inflorescence and epicarp of the nut is orange. Sucrose content of the tender nut-water is relatively high (5 - 6½%) furnishing a delicious refreshment. Oil is said to be of medicinal value and it has the peculiar characteristic of having a higher melting point than ordinary coconut oil. This form breeds true to type (about 80%).

(*b*) **Form navasi thembili:** Upper surface of the leaf mid-ribs, inflorescence and the epicarp of the nut is orange. Mesocarp of the tender nut is sweet and edible. Endocarp is very thin. Endosperm is thin and hard.

The variety aurantiaca appears to be confined in distribution to only Sri Lanka.

The form *typica* is the best producer as a commercial plantation crop. Other types are grown on a minor scale especially the form *thembili* for consumption as immature nuts.

Table 8 presents a summary of some quantitative characters of nut components of the forms of coconuts in Sri Lanka.

Table 8. Nut components of forms of coconuts found in Sri Lanka

	Unhusked nut			Husked nut		Shell		
	Length (*cm*)	*Width* (*cm*)	*Volume* (*ml*)	*Volume* (*ml*)	*Weight* (*kg*)	*Thickness* (*mm*)	*Weight* (*g*)	*Thickness of Endosperm* (*mm*)
Variety *typica*								
1. Form *typica*	21.8	19.8	3200	870	0.71	3	159	15
2. Form *Navasi*	22.6	19.3	3175	877	0.62	3	170	13
3. Form *gon thembili* ...	22.6	16.5	2535	787	0.68	3	198	13
4. Form *ran thembili* ...	21.8	19.3	3728	857	0.82	3	198	14
5. Form *pora pol* ...	22.9	16.5	1870	683	0.54	6	227	13
6. Form *bodiri*	11.4	9.1	606	218	0.20	2	51	10
7. Form *kamandala* ...	26.9	22.6	5922	1760	1.59	3	323	14
8. Form *dikiri pol*... ...	—	—	—	—	—	—	—	—
Variety *nana*								
9. Form *pumilla*	19.8	13.7	1457	367	0.28	2	71	11
10. Form *eburnea*	19.1	14.7	1591	474	0.43	2	88	12
11. Form *regia*	19.1	12.4	1140	334	0.28	2	57	11
Variety *aurantiaca*								
12. Form *thembili* (King coconut)	20.8	13.5	1394	559	0.40	2	170	12
13. Form *navasi thembili* ...	19.3	14.5	1573	525	0.45	2	99	12

SECTION III

PRODUCTION OF PLANTING MATERIAL

NURSERY TECHNIQUES

SELECTION AND TRANSPLANTING OF SEEDLINGS

CARE OF YOUNG PLANTATIONS

CHAPTER 5

PRODUCTION OF PLANTING MATERIAL

Introduction

Coconut is a perennial crop and its economic life is generally over sixty years in the case of commercially popular varieties. The extent of coconut cultivation in Sri Lanka is over 466,300 hectares (over 1.15 million acres). Many of these lands have been brought under coconut in the recent past. This figure is probably not precise because of the popular cultivation as a home garden crop in mixture with other trees of domestic utility. Demand for coconuts and coconut products has been on the increase since the inception of the coconut industry in Sri Lanka. A matter of great concern is that national demand for coconuts and coconut products has increased steadily with increasing population and rising living standards, while coconut production has been alarmingly stagnant over the past few years. Considerable losses of trees have also resulted from urbanisation, road and power distribution and increased demands by the building trade. It is of utmost importance that this situation be remedied early to ensure that viability of coconut as an important component of the country's economy. Replanting of senile stands and cultivation of new areas of coconut are necessary for enhancing production. The present section deals with the subject of promoting coconut production by improved planting methods and describes methods for the production of quality planting material and the selection of seednuts for planting.

Planting Material

In a crop with a long productive life, the importance of employing good planting material is self-evident. On this will rest the chances of getting the best return from the heavy investments of money, land-space and labour that are required. The quality of the planting material used initially to establish a plantation is therefore of utmost importance.

Coconut trees display great variability in nut yields. Detailed studies have revealed that a healthy coconut tree yields on average about 60 nuts per tree per annum (equivalent to a yield of 8,000 nuts /hectare/annum. In a typical stand of twenty-three per cent of the trees produced over 80 nuts per tree per year contributing to about 32 per cent of the total nut production. Seventy per cent of the palms produced 40 - 79 nuts per year giving rise to 65 per cent of the total crop. About seven per cent of the palms

contributed only three per cent of the total crop yielding less than 40 nuts per palm per year.

Although some of this variability is probably due to the location of certain trees in particularly favourable pockets of soil, clearly some of it is undoubtedly due to the superior genetical make up of the best producers. One method of increasing production is therefore to identify such superior palms capable of transmitting their favourable traits to their progeny and to establish plantations with such type of seedlings. Another method is to recognise palms with favourable qualities and to deliberately cross them in the hope that the desired features of the parents will complement, combine or enhance one another in the progeny.

Mother Palms and Seed Coconut Selection

Genetic propensity towards desirable traits possessed by a palm is transmitted to the daughter seedlings through the nut. Pollination behaviour of a particular palm (whether selfed or crossed) will however affect the degree to which the characters are likely to be transmitted. The simplest method of Crop improvement is by mass selection. The selection of mother palms is based on three major sequential steps, namely

(*a*) selection of suitable blocks within high yielding estates,
(*b*) selection of the best palms within the blocks, and
(*c*) selection of seednuts from the selected seed (or mother palms.)

Selection of Suitable Blocks

From available crop statistics, an average healthy coconut palm should bear more than 60 nuts per year. High yield in a palm may be due to its genetical make up or due to favourable soil and other environmental conditions.

Estates with high yields are chosen and the highest yielding blocks within them are next identified. It is rather important that entire blocks with high yield are employed because the seednuts gathered are open pollinated. In such a situation when any nearby palm could function as male parent it would be prudent to ensure that as far as possible the tree supplying the pollen is also inherently a good performer. Incidentally, it is relevant to mention that it is possible for every nut in a single bunch to have been fertilized by a different pollen parent.

Palms which in spite of being on average or below average soils are nevertheless high yielders would be the most advantageous individuals to be selected as mother palms.

Fig. 8. A low yielding palm and a high yielding mother palm.

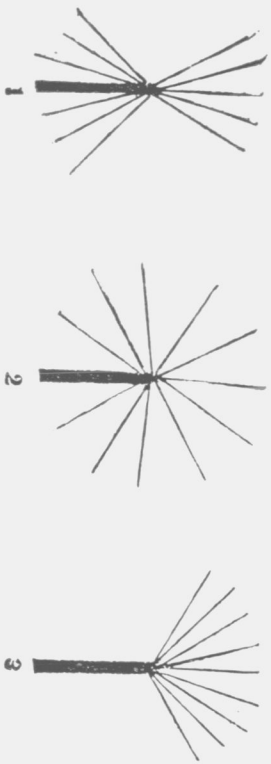


Fig. 7. Orientation of leaves on the crown.

Selection of Seed Palms

After the blocks have been chosen, palms with desirable visible characters are selected. Such characters sought are as follows:

The *stem* should be uniformly stout with the leaf scars situated close to each other. Very tall palms are avoided.

The leaves should be stout and well dispersed around the crown (Fig. 7(2). The palms whose crowns resemble 7(1) and 7(3) should be avoided.

The *crowns* should be well stocked with nuts at all stages of development. The bunch stalk should be short with no tendency to droop. Palms bearing seasonally or having sections of the crown empty should not be selected as mother palms.

The *nuts* should preferably be round with a high husked nut weight.

Mother palms that have been selected as above, should ideally have their yields (number of nuts), the weight of husked nuts and/or copra production recorded for at least three consecutive years. Finally, those palms yielding more than 75 nuts per palm per year with an average husked nut weight exceeding 680 g. qualify to be considered as mother palms. Finally ripe seednuts are harvested from the selected palms with harvesting being done monthly or bi-monthly.

The nuts harvested should be conditioned (see page 36) and planted in a nursery. When the seedlings have developed those for planting are chosen by a rigid selection procedure (see Chapters 6 and 7).

It has been found that although certain mother palms have consistently produced high yielding progenies, some others have given rise to average or below average progenies. One obvious reason for this variation is the cross-fertilisation that naturally taken place in the commercial tall variety where the female flowers need to be fertilized by pollen from a male flower of any of a random collection of palms which could be of varying yield potential. However, through a rigid selection of seednuts and seedlings derived from them, a 12 - 15 per cent overall improvement in the yield may be anticipated.

Controlled Pollination in Coconut

Although mass selection procedures as outlined above can result in improved progeny, the deliberate creation of new combinations of characters that can be obtained by mating of selected parent type represents a clear advance. Indications are available already that such procedures can result in very substantial gains in coconut performance.

When two forms of coconut having desirable qualities are crossed, the resulting offspring could favourably combine the good qualities of both parental forms. It is not uncommon for such matings to provide offspring that surpass both parental types in performance. This phenomenon which suggests that an additive effect of desired traits is displayed by the offspring is referred to as "Hybrid vigour."

A further observation with coconut is that certain palms possess the ability to transmit undiluted, their high-yielding capacity irrespective of the nature of the other parent. This phenomenon has been described as "prepotency". It has been surmised that the use of pollen from such prepotent palms on high yielding female parents can result in a yield improvement of about 25-30%.

Hybridization Between Coconut Varieties

Though there is a number of varieties and forms of coconuts, the majority of them are not commercially grown. None of the naturally occurring varieties or forms combine all of the favourable characters of precocity (earliness) in bearing, nuts that are simultaneously numerous and large and producing a good quality copra. Certain types however do possess one or more of these traits. Experiments carried out to recombine these characters have been a success in providing hybrids or strains that have early bearing and high yield qualities. However certain undesirable characters in the parents also may show up in the progeny. However by choice of appropriate parent types for hybridisation, the advantage can be made to outweigh any disadvantage.

The outstanding example, repeated in several countries, is the combination of dwarf and tall varieties. Dwarfs are generally early bearing with numerous nuts in the bunch but the nut size is small and the copra produced of poor quality. There are also seasonal in bearing and markedly susceptible to drought. Most tall types have properties opposite to the dwarf in most of these characteristics. When crossed, the hybrid progeny is generally intermediate in these traits but or balance, greatly superior to either parent on its own.

Hybrids between Dwarf × Tall are generally early flowering and high yielding. (See Fig. 9). Flowering commences in 3 - 4 years from planting. The advantage however narrows under sub-optimal soil, light, moisture, fertiliser and other management conditions.

Dwarf × Tall hybrids are not drought tolerant and they generally do not thrive, in areas subject to high moisture stress, or in areas having shallow, gravelly soils.

The best known of the hybrids are the Ivory Coast's PB 121 (Malayan Yellow Dwarf × West African Tall) and Malaysia's MAHA (Malayan Red Dwarf × West African Tall). Sri Lanka's Green Dwarf × Ceylon Tall is known as CRIC 65.

Crosses Within the Same Variety

It is tempting to presume that the early outstanding successes in crosses between dwarf and tall varieties have tended to obscure the potential available for improvement by crosses within the same variety (Tall). The question does not require the same relevance in the case of the Dwarfs which are naturally self-pollinating and therefore likely to be homogeneous. Sri Lanka has experience of very satisfactory results by crossing tall individuals (var. *typica*, form *typica*). Scope clearly exists for crosses between forms within the variety typica.

In nature the chances of a high yielding palm being fertilized with pollen from an equally high yielding palm are remote because such palms occur only in small numbers in average plantations.

Selected extremely good yielders, however, could be deliberately crossed with similar individuals by artificial pollination. With the enormous range of types among the tall variety, there is clearly much potential in Tall × Tall crosses.

Tall coconut palms are selected based on vegetative and yield attributes according to the criteria laid down on page. Individuals yielding over 100 nuts and 22 kg of copra per year would be suitable candidates for such a breeding programme.

The offspring resulting from Tall × Tall type crosses are tall in habit, and late-flowering (5 - 8 years to flower depending on the soil conditions, climate and management). They are very good yielders being drought tolerant and these are suitable for planting, in all situations suitable for coconut culture, in Sri Lanka. (Tall × Tall seedlings are available under the distinctive name CRIC 60".

The Dwarf × Tall hybrid produced in Sri Lanka reacts adversley to climate stresses, soil unsuitability and poor management. It is regarded as being capable of sustained high production in only about 1/3rd of the total coconut extent and subject to the proviso that management (fertilizer, irrigation, drainage, weeding and cultivation) standards must also be very much above the average for the local smallholder. The procedures involved in producing seednuts through controlled pollination are discussed below.

The Techniques of Controlled Pollination

The principle behind controlled pollination is simple. It consists essentially of preventing the fertilization of any of the female flowers on the palm concerned by any pollen other than that desired. As coconut inflorescences bear both female and male flowers, the latter should be removed before they could begin to release any pollen. This procedure is called "emasculation" and must be meticulously carried out if chance crossings are to be prevented. The atmosphere in a properly managed hybrid seed production unit should be completely free of pollen from palms that are not designed to father the particular cross. Several growers have utilised Institute supplied pollen to raise their own seednuts.

Hand Pollination

The techniques of hand pollination is of practical use in small production units. If the necessary precautions are strictly observed, good results can be obtained.

The equipment necessary for an estate wishing to undertake hand pollination is as follows:

1. A refrigerator with deep-freeze compartment for pollen storage.
2. Two dozen soda-glass test tubes 75 mm × 10 mm.
3. 60 clear polythene bags (gauge 200—size, 90 cm × 60 cm).
4. One dozen No. 2 paint brushes.
5. One desiccator 150 mm diameter or any convenient similar size with a perforated shelf.
6. 100 filter papers to fit the desiccator shelf.

Fig. 9. D×T. hybrid bearing palm.

7. A pair of secateurs.

8. Surgical cotton wool.

9. 2.5 litres 98 - 99% sulphuric acid (to be diluted) to 43.4% for use.

10. Rectified spirits.

11. 22 kg cotton waste

12. Galvanized iron sheets (for tags), twine, paint.

This equipment and material will be sufficient for a unit of fifty palms for pollination.

Selection and Preparation of Palms

Palms should be selected according to the type of hybrid desired (see above). Husks are tied with ropes to the trunks of the selected trees at a distance of about 60 cm apart to facilitate climbing (see Fig 10). The rope (usually coir rope) should be treated properly before using, by impregnating it with a mixture of engine oil, kerosene oil and tarnap (8 : 4 : 3 parts respectively). The treated rope withstands deterioration due to weather and attacks by rodents.

The selected palms would generally be heavy bearers and one or two fruit bunches may need to be removed for easy access to the crown. It is desirable at the same time to remove all old bunch stalks, butt ends and other debris as these are likely places for rats to breed. (Rats can damage the pollinating bags and immature nuts). The palms should be preferably numbered to assist in maintaining yield records. It is advantageous to maintain a record for each palm with the dates of opening of the inflorescences, dates on which emasculation and pollination were carried out etc.

Emasculation and Bagging

The sequence of events that occur after opening of the inflorescence have been briefly described (see page 18). The operations that have to be carried out in a palm being used for cross-pollination are closely related to these changes. Methodical and timely action are necessary to carry out hand pollination, successfully.

The inflorescence is examined on the 18th day from the recorded date of opening of the spathe and the probable date of receptivity of the female flower is noted. Generally the female flowers become receptive on about the 21st day. Three days prior to the date of receptivity in female flowers, the spikelets bearing the male flowers are removed (emasculated) with secateurs. The cut is about three inches above the closest female flower on each spikelet. The remaining male flowers are removed. For convenience of the operation any female flowers in excess of thirty are removed. Figure 11 shows a correctly emasculated inflorescence bearing the female flowers which are still not receptive. This emasculated inflorescence is enclosed in the tubular polythene bag of the specified dimensions. The lower end of bag is tied firmly round the stalk over a layer of cotton waste and the upper open end is tied (Fig. 12).

Pollen and Pollination

Pollen from selected tall palms or from dwarf varieties are obtainable in sealed glass-tubes from the Coconut Research Institute on request. The pollen should be transported in a flask with ice and stored in a refrigerator preferably at deep-freeze temperatures until required. It is important to ensure the viability of pollen being used in pollination work to ensure successful fruit-set. It is recommended that the pollen for the day's needs in the field should be taken packed in ice. The glass-tube with pollen, a glass test tube, a test tube with some rectified spirit and a brush, should be carried by the operator. The test tube and the brush should be sterilized with some rectified spirit and be dried before use.

The receptive stage of the female flowers can easily be recognised through the transparent polythene bag (See page 18). If the female flowers are receptive the glass tube with pollen is broken and the pollen tipped into the test tube. The glass test tube with the pollen sample and the brush is inserted into the bag through the lower end of the bag by loosening that end. The brush dipped in the test tube is dusted on the stigmatic surface on the receptive flowers. The bag is firmly tied after withdrawing the test tube and the brush.

It is necessary to do a second pollination usually on the day following the first pollination. Pollination is best done either early in the morning or late in the evening. The bag is removed on the third day following the second pollination and the nuts will be ready for harvesting in 11 - 12 months if the pollination is successful.

Fig. 10. Husk tied selected palm to facilitate climbing.

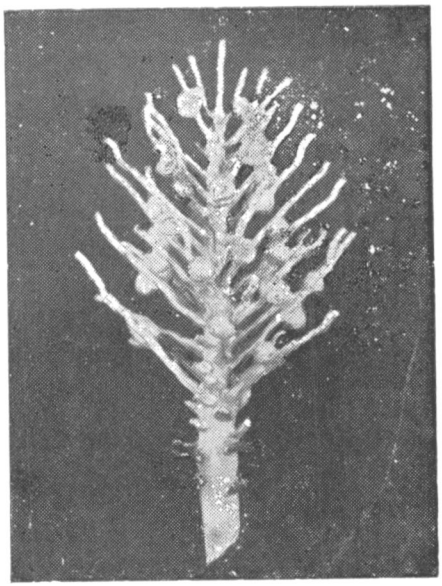


Fig. 11. Correctly emasculated inflorescence bearing female flowers.

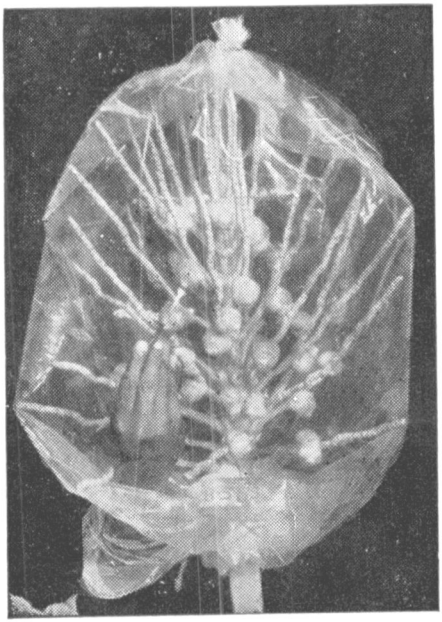


Fig. 12. Female flowers bagged for pollination.

Any pollen, remaining after the day's pollinations, could be stored for further use. The test tube with pollen should be plugged with cotton wool and kept in a desiccator containing 43.4 per cent sulphuric acid. The desiccator should be kept in a refrigerator at 0 - 5°C. It is desirable to change the acid in the desiccator every fortnight.

Assessment of the Crop

The number of nuts obtainable from hand pollination is usually less than that from natural pollination. A fair assessment of the nuts that will develop can be made by counting the number of button nuts developing eight weeks after pollination. A further, 10 - 15 per cent of the button nuts may fall off. The nuts developing on the crowns could be followed if the button nuts are marked and any nuts that fall prematurely are counted.

Isolated Seed Gardens

While the procedures described above are feasible with small production units they would clearly be cumbersome for production of seednuts on any appreciable scale.

The choice then is for the establishment of seed gardens or pollination gardens. Pollination gardens are generally located at a safe distance away from the nearest coconut palms. Preferable to only being located away from other coconut palms, it is preferable to have a sizeable forest or other tree crop barrier of the greatest breadth possible.

By reason of their location in such manner, these production blocks are often referred to as "Isolated Seed Gardens". Coconut palms desired to function as the female parent are planted in the garden. Such palms could be of the dwarf form or a tall form according to the particular combination of parents as planned. As the dwarf types are easy to emasculate and as their nut numbers are large, they are generally preferred as the female parent. All three dwarf colour forms—green, yellow and red have been used in hybrid production.

There are two major palm arrangements depending whether pollination is to be "natural" or "artificial". If for natural pollination, their palms desired as the male parent are planted in a regular pattern of distribution within the female population. The palms intended to be the female are vigorously emasculated. Then only pollen from the pollinator palms should be available within the garden.

Experiments conducted to determine the density of pollinator palms (tall) necessary in a plantation of dwarfs to ensure maximum production of seednuts, have tried alternate rows (50% males), every fourth row and every fourth palm in each row (15% males) and so on. Adequate pollination appears to occur even when the ratio is 9 talls to 8 dwarfs.

Where artificial pollination is the chosen method, the garden is planted up entirely with the female parent. All pollination is effected by dusting within the grove with pollen brought from outside the garden. This arrangement maximises on the density of seednut producing palms by saving the space otherwise to be occupied by the pollinator palms. It also allows the flexibility to change at any given moment to different types of pollen. It would even be possible to pollinate the buttons on an inflorescence with a mixture of pollen types and so obtain a number of hybrids borne on the same bunch. The disadvantages are the additional expense (pollen is expensive) and labour required and also the ever present risk of spreading any possible pollen-borne diseases—especially when pollen is imported from abroad.

A combined practice where both parental forms are planted together but where pollen is also artificially dusted, is sometimes referred to as "assisted pollination."

The forest barrier round the isolated Seed Garden in Sri Lanka is to prevent any unwanted coconut pollen reaching the garden. The female palms are either green or yellow dwarfs and they are inspected daily, by a work gang who ensure that all dwarf palms are emasculated. The male parental trees are of the common tall type but derived from selected excellent tall palms. They are allowed to release their pollen into the air. Insects (particularly bees) also play a significant role in pollinating coconut. The pollen of the paternal form pollinate the receptive female flowers of the maternal parent.

Assuming that the pollination-garden is free from foreign coconut pollen, all nuts born on all female parental trees are fertilized by the pollen from trees left unemasculated. The seednuts are harvested when ready and are planted to provide the progeny seedlings.

Isolated seed gardens allow an opportunity to raise a large number of hybrid types with comparatively low input of human labour. Although the exact reason is unknown, it appears that dwarf palms naturally pollinated produce more nuts than those where pollen is dusted. The type of seed garden of the mixed type as grown in Sri Lanka is favoured for the several advantages

it bestows. In a second seed garden in Sri Lanka, an existing block of very high yield was selected, all sub-normal palms rigorously removed and dwarf palms (which will be emasculated once flowering begins) planted.

Isolated seed gardens are very costly to establish for the private grower. The capital investment can be quite high and trained staff is essential as the emasculation of female parent trees needs skill and experience to carry out effectively. Careless operation can be disastrous. In our own Seed Garden, illegitimacy was less than 1 per cent when tested recently.

Selection and collection of Seednuts

The nuts to be utilised as seednuts are generally harvested only when they are fully mature, *i.e.*, when about 12 months old. Recent studies carried out in India and Sri Lanka have shown that the second bunch of nuts, about 11 months old, can also be used as seednuts. No difference in the performance of the seedlings derived from the two groups of seednuts are seen either in the early or the bearing stage.

In mother palms delected for desired economic and morphological characters, selection of seednuts should be done methodically. Generally, medium sized heavy nuts with acceptable shape are selected as seednuts. Nuts situated towards the top and bottom extremities of the bunch are not always uniform. Some may be under sized and relatively light and therefore should be rejected.

Conditioning of Seednuts

The seednuts after harvest are not planted immediately in the nursery. They are generally stored in the shade for about a month till the husk becomes brown and partially dry. Furthermore any difference in ripeness among the nuts are probably corrected with storage.

CHAPTER 6

NURSERY TECHNIQUES

Seednuts of coconuts are planted in a nursery bed prior to field planting. This procedure allows the selection of the vigorous and healthy seedlings for transplanting, easier control of pests and diseases, and more efficient watering of the seedlings during their young stages. The following nursery practices are recommended.

Selection and Preparation of Site

The selection of an appropriate site for a nursery is most important. The land should be flat and well drained. The soil should be sandy or a light loam but the fertility of the soil is not as important as the texture and other physical properties. Nutrient deficiencies which are not met by stores within the nut could always be corrected by fertilizer applications. It is important to establish the nursery away from heavy shade as the lack of sufficient sunlight could retard proper growth of the seedlings or result in their becoming spindly. The seednuts should always be kept moist. Drying of the seednuts under hot sun can result in poor germinations and can cause cracking of nuts. In order to irrigate the seednuts during dry spells, the nursery should be sited near a reliable water source. The nursery should also be close to the area of replanting to cut down transport costs and damage to seedlings through excessive handling.

Interspaces among coconut palms — provided they are tall enough to avoid over-shading can be satisfactory if other conditions are favourable. The width of the bed should not be more than five seednut rows wide, to allow for early access, but can be as long as convenient. Narrow beds facilitate early watering and regular inspection and other operations. The beds should be raised slightly separated by shallow drains designed to lead away any excess water during heavy rains.

The spacing of the seednuts in the beds largely depends on the length of the time the seedlings are likely to be in the nursery before transplanting.

After the soil has been loosened, up to 5 straight trenches, each about 25 cm wide and about 15 cm deep are made about 25 cm apart, and parallel to each other. The nuts are then laid down flat in the trenches about 25 cm from the centre of one nut

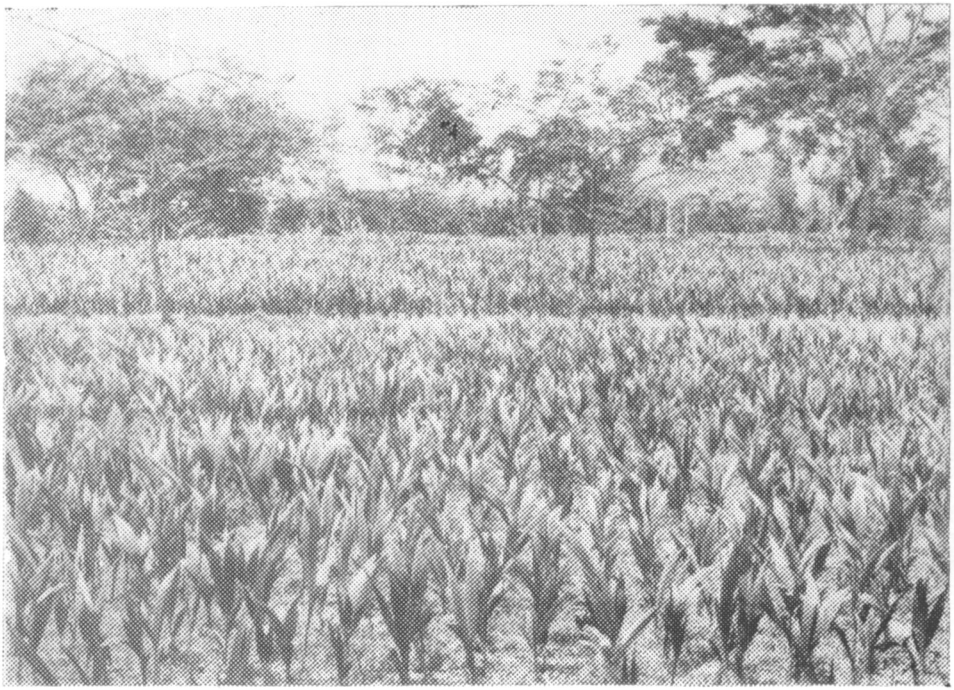


Fig. 13. A view of a coconut nursery.

to the next. The proximal end of the nuts should point in the same direction. The seednuts are laid with the narrow face of the nut downwards, so that the soft eye of the nut is positioned towards the top. Nuts in adjacent trenches are laid so that they alternate. Soil is filled around the nuts leaving part of the top of the nut exposed to facilitate sprouting. The above spacings would accommodate about 50,000 nuts/ha (20,000 per acre).

At least 75 per cent more seedlings than are required for transplanting should be germinated in the nursery for planting. To obtaining sufficient seedlings for 40 ha (100 acres), a nursery space of about 0.13 ha (1/3 acre) is generally required.

Regular watering at least thrice a week should be carried out in dry weather depending on soil and climatic factors. Generally a volume of water around 4 1/2 (equivalent to 4 mm rain fall) per application is recommended.

Nursery beds should be mulched particularly in the drier areas. Mulching helps in keeping the weeds down and in conserving moisture ; Coconut leaves are usually adequate for this purpose. Coir dust and husks used as a heavy mulch have been shown to give poor germination and less satisfactory seedlings. However, applied as a reasonably shallow and uniform layer, immediately after planting and thorough soaking of the soil, coir fibre dust as a satisfactory mulch. With much of any kind, particular vigilance should be exercised to ensure that serious termite infestations do not appear. If they do, appropriate measures should be taken to bring them under control.

Owing to the satisfactory moisture conditions maintained by a good mulch. early and better germination of seed nuts is obtained.

Under good conditions the seedlings are ready for replanting in about 9 - 12 months. Fig. 13 presents a view in a coconut nursery. Although older seedlings could also be used, they are more difficult to transport and may also display poorer establishment because of a higher shoot/root ratio and consequent susceptibility to water stress.

Pest Control in Nurseries

Constant checks to detect insect pest attacks need to be carried out in nurseries. The most common pest of seednuts and young seedlings is termite. Damage by scale insects and locusts are more rare and of minor importance. For control measures of these pests see page 96 Chapter 14.

CHAPTER 7

SELECTION AND TRANSPLANTING OF SEEDLINGS

Selection of the seedling is the first step in bringing up a healthy coconut palm. There is strong experimental evidence to show that early germinating seednuts and healthy, vigorous seedlings give rise to high yielding adult palms. The advantage resulting from the selection of good seedlings has been shown to be a yield increase of 10 - 12%.

Selection of Seedlings

Rigorous selection of seedlings, totally discarding any showing weak growth or other undesirable features is likely to yield rich returns in the long run. Ideally, a seedling should still be attached to its mother-nut by a stout collar, be rich green in leaf colour, have three or four healthy leaves where the leaflets have not yet separated, be stout in habit and possess a good development of thick, healthy and fresh roots.

Although not traditionally practised in Sri Lanka, several countries consider it worthwhile to pre-sprout seednuts in special sand beds and to transfer those that germinate early into earth-filled polythene bags (usually black, heavy gauge, diameter about 30 cm and height of 40 - 50 cm). The bags are spaced about 1 m apart in the nursery. When the seedlings are ready, the bags are transported into the field and the bags lowered into the planting holes, carefully ripped and removed, and the plants earthed-up.

The advantages of this method is principally in reduction of damage in transport and elimination of a setback in growth due to "transplantation shock" or root damage. The disadvantages are the additional cost of the bag, reduced economy in the use of nursery space and the greater difficulty and expense in handling the heavy soil-filled bags.

Another practice which would justify careful examination in Sri Lanka is the practice of applying fertilizer to nursery plants. This is presently not a general practice in this country although *ad hoc* applications are sometimes made to "brighten up" the appearance of nursery plants.

The favourable criteria looked for in the final selection of a nursery plant are :—

Early germination of the seednuts

Rapidity of growth of seedling

Sturdiness and appearance

Freedom from pests and diseases.

Under favourable nursery conditions, nuts of the tall variety of coconut germinate in about 11 - 12 weeks after planting. The percentage of germination reaches a maximum in about 17 - 18 weeks and does not increase thereafter. Since palms derived from early germinated seedlings flower earlier and are more productive than those derived from late germinations, it is the practice in nurseries to uproot any seednuts that have not sprouted at the 16th week. Generally 5 - 15 % of seednuts get rejected at this selection.

Vigorous seedlings suitable for selection have stout stems, good girth at the base, a large number of roots and leaves with prominent veins and short stalks spreading outwards and not merely pointing upwards. Seedlings that do not meet these requirements should be rejected. Further any seedlings affected by pests or diseases or deformed or abnormal should also be rejected. On the standards enumerated about, it is reasonable to expect that anywhere between 40 - 60 % of the seednuts planted will end up being rejected.

Rejected Seedlings

Rejected seedlings need not necessarily be a discarded item. Even after eight to ten months in the nursery, over half of the kernel still remains and a low grade of copra can be turned out. About 106.4 Kg of Grade 3 copra have been obtained from 1,000 rejected seedlings. The copra thus obtained is unusually rich in oil.

There are several advantages in growers establishing their own nurseries. The major ones are the least of transport and the convenience of having their seedlings available on hand for immediate planting when favourable weather conditions set in.

In Sri Lanka, State does however operate a large number of nurseries scattered throughout the coconut growing areas for the convenience of growers in obtaining their seedling requirements at the correct time and in close proximity to their land and at a highly subsidised price.

Removal of Seedlings

Seedlings should be removed from the nursery only just before they are required for transplanting. Seedlings should not be forced out but their roots should be neatly eased out of the soil and trimmed for ease of transport. Pruning of roots is not considered harmful although it must result in some delay in establishment and retard subsequent growth. Seedlings once removed from the bed should be transplanted as soon as possible, certainly within 10 days of removal.

Preparation of Land and the Timing of Replanting

The land in which the seedlings are to be transplanted should be prepared according to the conditions prevailing and the situation of the land. If the seedlings are to be underplanted, no special preparation of the land needs to be done but if it is in a new clearing the stumps and other plant debris should be removed. Once the lining out for seedling planting has been carried out, any coconut or other trees which are closer than six feet (2M) from the proposed seedling holes should be removed as completely as possible.

If the land to be planted is an old rubber estate, then all rubber trees should be uprooted completely before attempting to transplant the coconuts (see CRI Advisory Leaflet No. 21 for details).

If the land is sloping and soil erosion is evident or likely contour drains should be opened to minimise surface run-off during the rains. The frequency of drains will vary with the gradient of the slope. A cover crop is an advisable means of maintaining good soil conditions. In low lying areas, drains should be cut to help remove excess water. For a detailed account of these management procedures see Section IV. Planting of seedlings should ideally be done at the beginning of the monsoon rains. In the Wet and Intermediate Zones which receive rains from both the North-East and South-West Monsoons, either season could be employed for transplanting. The Dry Zone has only one growing season — the North-East Monsoon.

METHODS OF PLANTING OF SEEDLINGS

Size of Planting Hole

In loamy soils, the size of the planting hole should be 0.5 m × 0.5 m. × 0.3 m. In harder, gravelly soils the seedling hole should be 1 m × 1 m × 1 m. When the latter size of hole is employed in new clearings, it is filled with a mixture made of good top soil, ground dolomite (2 kg) and saphos phosphate (450 gm). If replanted or used to fill in a vacancy, dried cowdung (9 kg) and

wood ashes or kitchen ashes (4.5 kg) should be used besides the above materials. Sulphate of ammonia (.45 kg), poultry manure (9 kg) or goat manure (4.5 kg) or compost (16 kg) may be used as an alternative to 9 kg of dried cow-dung. Muriate of potash (225 gm) may be used to replace the wood ashes or kitchen ashes (4.5 kg).

A worker could dig about fifteen planting holes of the larger size per working day.

Where termite infestations are to be expected, it is advisable to treat the seedlings by dipping the nut in an appropriate solution of insecticide (see page 96).

CHAPTER 8

CARE AND MAINTENANCE OF YOUNG PLANTATIONS

Once the seedlings are planted, proper care and maintenance are important. The critical stage in the life of the coconut palm is the first 3 - 4 years. Neglecting the seedlings during this phase could severely set back the growth of the seedlings and a poor start significantly retards subsequent performance and could influence productivity for many years.

The major management steps are as follows :—

1. Fencing
2. "Supplying" of casualties or unthrifty plants
3. Watering
4. Fertilizer applications
5. Weeding
6. Pest control and
7. Growing cover crops.

1. Fencing

Newly planted seedlings should obviously be protected from cattle, goats and wild animals. If the seedlings are concentrated in a sizeable area, a fence enclosing the area should be erected. In large commercial plantations barbed wire fences of 5 strands are normally employed. If the seedlings are isolated, they should be protected individually. Individual fences are usually constructed with coconut fronds or by piling husk barriers. Sprinkling of a slurry of cowdung on the leaves is usually effective against cattle damage but this treatment needs repeating periodically, specially after heavy rains.

2. Replacement of Casualties

Vacancies should be filled in at the end of the first year of transplanting. Any noticeably backward plants or any seedlings appearing to have suffered damage by some cause or another need

be replaced with healthy, good seedlings. A reserve set of seedlings is therefore convenient to ensure timely replacement. A re-supply rate of about 5 % is normally to be expected during the first year.

3. Watering

The seedlings should be watered at least thrice a week if dry weather follows transplanting, continuing the watering until the seedlings are firmly established. Wherever possible, daily watering of seedlings is recommended, but over a large area this may be impractical. Then about 18 litres (4 gallons) of water should be supplied to a seedling at least twice a week, particularly during its first year of development.

4. Fertilizer Applications

Proper fertilizing of the seedlings after their establishment will ensure, vigorous growth, early, continuous and satisfactory yield from the palms. Major plant nutrients, nitrogen (N), phosphorus (P) and potassium (K) are essential for the healthy growth of young palms. Young palms require more nitrogen and phosphorus but lesser potash than do adult palms. Proper balances should be maintained between these major elements as imbalances and deficiencies could also predispose the seedlings to pest and fungal attacks.

There is evidence to indicate the vital importance of systematic and adequate fertilizer applications.

It is known that next to nitrogen, phosphorous and potassium, magnesium (Mg) ranks highest in the quantities of this nutrients taken up by the coconut palm. Magnesium is an element that is needed in the formation of chlorophyll which is the pigment primarily concerned in photosynthesis.

Fertilizer mixtures with a high proportion of nitrogen and phosphorous are recommended for application until the bearing stage. Thereafter, several different fertilizer mixtures have been recommended by the Coconut Research Institute based on experimental findings. The fertilizer mixture (also known as the CRI General Mixture) for young palms is as follows:-

Sulphate of ammonia (20.6 % N) 4 parts by weight

Saphos phosphate (27.5 % $P_2 O_5$) 3 parts by weight

Muriate of potash (60 % K_2O) 2 parts by weight.

To ensure continuous availability of the nutrient to the developing palms, the fertilizer should be applied in split doses, thrice or four times a year. The fertilizer should as far as possible be used immediately after mixing. Where prompt use of the mixed fertilizer is not possible, it is preferable to obtain unmixed fertilizer ingredients to be mixed in appropriate proportions as required.

Rates of Fertilizer Application

The dose per application for young plantations depends on the ages of the seedlings and the nature of the soil. A higher fertilizer dosage is recommended for seedlings in all second plantations and in new plantations on sandy soils such as coastal marine sands. Such soils are usually poor in essential nutrients.

Table 9 Rates of CRI General Fertilizer Mixture to be used on young coconut palms until bearing

Time after transplanting	*Rate per palm new clearings (g)*	**Rate per palm for 2nd Plantation (g)*
6 months	225	675
1 year	225	675
1½ years	450	675
2 years	450	675
2½ years	675	900
3 years	675	900
3½ years	900	1.1 Kg.
4 years	900	1.1 Kg.
4½ years until bearing	1.1 Kg	1.35 Kg.

*Also for new plantings on sandy soils where fertility is low and percolation of rain water is rapid.

If the seedlings are of vigorous, high-yielding strains (*e.g.*, Tall × Tall, or Dwarf × Tall), then the fertilizing should be as given in Table 10. CRI General Fertilizer Mixture can be used in manuring the hybrids.

Table 10 Rate of CRI General Fertilizer Mixture recommended for hybrid coconut

Time after transplanting (Years)	*Rate per palm per year (Kg)*			
	Tall × Tall (CRIC 60)		*Dwarf × Tall (CRIC 65)*	
	New Clearings	*Second Plantations*	*New Clearing*	*Second Plantations*
1	0.45	1.35	0.90	1.80
2	0.90	1.35	1.35	1.80
3	1.35	1.80	2.25*	2.25
4	1.80	2.25		2.70*
5	1.25*	2.70*		

*Continue until bearing.

In addition to the above fertilizer mixture, dolomitic limestone should be added to the soil around seedlings of a second plantation, after the third and the sixth year at the rate of 1 kg per seedling. Dolomite should not be mixed with the fertilizer mixture mentioned above as it can cause the breakdown of nitrogen fertilizer components. It is best that an interval of 4 - 6 weeks intervenes between dolomite and fertilizer application. However, dolomitic limestone can be applied simultaneously with fertilizer, provided that, the fertilizer is worked well into the soil within a few hours after application.

Frequency and Time of Fertilizer Application

Rapidly growing young seedlings respond better to several small and frequent applications of fertilizer than for occasional large doses of fertilizer. Thus, fertilizer in the initial years should be applied at least half yearly if more frequent applications are impracticable. Quarterly applications of fertilizer is recommended especially for light, sandy soils. Fertilizer application combined with weeding operations will cut down costs and have the added benefit of incorporation of weed residues into the soil.

Application of fertilizer should be carried out when the soil is moist. On light sandy soils, biannual fertilizer application should be done sometime after the heavy rains. Quarterly application is done at the beginning and towards the end of the monsoon periods. Particularly if the land has a tendency to become waterlogged, fertilizer should be applied after the heaviest rains are over.

Method of Application of Fertilizer

During the early stages of development (up to 12 - 18 months) fertilizer should be applied close to the base of the developing palm spread over a zone of about 30 cm from the base. Soils after fertilizer application should be lightly turned over with mammoties or mammoth forks. As the palm grows, this distance from the base should be increased up to 1.5 m at flowering.

On very steep lands however fertilizer should be applied in trenches of 1 metre wide and 15 cm deep around the palm.

Weeding

In respect of weeding, during the first three or four years from planting, more attention is required than at any other stage.

1.2 m radius around the palm should be kept weed free. Weeding should be done 3 - 4 times a year and the removed weeds should be put back in the same circle to form a mulch. Weeds should be removed or slashed down before the flowering stage to prevent further spread.

Coconut husks with the fibrous side down could be arranged close to each other as a mulch which would prevent weed growth appreciably which also acting as a mulch against water loss.

Pest Control

Major pests of young seedlings are cattle and termites. As discussed earlier, good strong fencing around the seedling should prevent damage by cattle. The fences should be strong enough to last for long enough until leaves of the young palm are out of reach of animals such as cattle and goats.

Termites which damage coconut at the seedling stage are found in all coconut growing districts in Sri Lanka and in some parts the incidence is more than in others. A detailed account of the termite pest is given on page 96. Occasionally black beetle (*Oryctes rhinoceros*) can be common in young coconut

palms and this could be controlled by regular surveillance observed for pest damage. Trained personnel can be employed in this task of removing the beetles from feeding sites in the crown of the young palms.

The fungal pathogens responsible for causing leaf damage particularly during the period prior to bearing are *Helminthosporium incurpatum* while *Pestalotioneis palmarum* may also be involved in this.

The incidence by the former is prevalent in areas deficient in phosphorus and rich in nitrogen. Therefore, proper nutrient balance of the soil should be maintained to safeguard young plantations.

Other pests and diseases on young seedlings are less common. However should any inexplicable damage is to be observed in the field, prompt control should be brought about (Refer to Chapter 14).

Cover Crops

The importance of cover crops arises from their role in fixing atmospheric nitrogen, circulation of nutrients. Soil moisture conservation and erosion control.

A cover crop offers protection to the soil from excessive drying and protects it from erosion and leaching by helping to break the force of torrential rain. It adds nitrogen to the soil. Cover crops are sometimes reported to retard the growth and delay bearing of young palms. However, the long term advantages outweigh the disadvantages. When cover crops are grown in new clearings, a circle of radius of 0.9 m should be left free of it and this area may be mulched with the cleared material.

Bearing of Young Palms

The time the seedling will take to commence flowering and bear nuts is largely influenced by the level of management and care that they have received; climate, soil conditions and the genetic make-up of the seedling. On good virgin soils even tall varieties begin to bear as early as in 5-6 years; Talls normally come to full bearing at about the tenth year when under planted. Dwarf varieties usually fruit as early as in four years. The dwarf $\times$ tall hybrids normally bear earlier than the talls, under proper management. After attaining maturity, plantation management procedures govern the return from the plantation, subject to climatic factors. Management procedures are therefore of utmost importance to ensure good yields and they are discussed in Section IV.

SECTION IV

A plantation which has reached the bearing stage must receive sustained attention with regard to proper management. The major aspects are in the management of soil conditions and of pests and diseases. Neglect of these will result in such serious losses that the coconut estate may eventually turn out to be unproductive. Weather conditions exert a strong influence on yield. Adverse weather conditions (*e.g.* drought) suffered successively can suppress yields, the effect lasting even after the weather has become favourable again. This is because a number of stages of bunch development are sensitive to dry conditions. There is the likelihood that well managed estates suffer comparatively less from adverse factors than neglected ones.

This section deals with the more important steps in the proper management of plantations in bearing. Chapters 9 to 16 included in this section deal with:—

Manuring of adult coconut palms

Soil and soil-water management

Weed control

Intercropping under coconut

Pests of coconut and their control

Diseases and disorders of coconut and their control and

Care of plantations.

CHAPTER 9

MANURING OF ADULT COCONUT PALMS

Among the crops entering world trade, coconut is perhaps one of the most neglected, in respect of fertilizer usage although fertilizer could be considered one of the most important factors in coconut cultivation. Investigations have revealed that the majority of coconut soils in Sri Lanka are deficient in the important plant nutrients nitrogen (N), phosphorus (P) and potassium (K). Magnesium, which is found to be an important element for healthy growth is lacking in many coconut soils, particularly in the gravelly and sandy soils of the Wet Zone.

Potassium has been shown to be the dominant requirement of the coconut palm. Application of potassium increases nut production and also gives rise to more favourable copra out-turns. Potassium improves the setting of female flowers while nitrogen and phosphorus increase the production of female flowers and nuts.

Visual symptoms of potassium deficiency are very common and easy to identify in the field. The first symptoms appear in the older leaves in the form of olive green to reddish brown spots. In advanced stages of deficiency, the older fronds turn completely orange yellow to reddish brown and leaflets dry up, starting from the leaf tips. The number of leaves gets reduced and both crown and leaves become smaller in size.

Nitrogen deficiency results in an overall dilution of the green colour of the leaves. The entire crown of the palm appears light yellowish green with the younger leaves still paler (water-logging, severe drought, heavy infestation with weeds and sulphur deficiency may also produce similar symptoms). The older leaves dry up and drop prematurely.

It is difficult to identify phosphorus deficiency in the field. The leaves of phosphorus deficient plants are generally abnormally dark green in colour.

Magnesium is required by plants for the production of chlorophyll. Lack of magnesium imparts a yellowish appearance to the leaflets particularly visible in the older leaves (see page 55). For soils where magnesium is deficient magnesium-fertilizer should also be added in addition to the normal NPK fertilizers.

It is uncommon to find lands, where the available potassium in the soil is adequate for the palms. Potassium deficiency reduces the productivity to such an extent that in some cases, restoration of potassium could double or treble yields. For best results, fertilizers should be applied to soil in appropriately balanced proportions. Based on several years of field experimentation, the Coconut Research Institute recommends fertilizer mixtures containing the major nutrients, Nitrogen, Potassium and Phosphorus. These mixtures are commercially available. In Sri Lanka, the fertilizer input for coconut is still far from sufficient.

Low fertilizer usage may in part be responsible for the poor and depressed returns from the coconut industry over the past few years.

Minerals absorbed by plants from soil, are steadily removed by palm product such as fruits, husks, shell, sap, falling fronds and also built into the more permanent structures — stem and roots. Nutrients in the soil are generally a non-renewable resource. Continued removal of nutrients by the palms will therefore tend to exhaust the soil and deplete it of important minerals. If these essential minerals are not returned to the soil, productivity is progressively diminished. One of the means available to ensure rapid increases in production is the application of fertilizer to coconuts properly and regularly at the correct time and according to the recommendations of the Research Institute. The returns to the grower from such an investment are assured.

There are several fertilizer formulations prescribed by the Coconut Research Institute. All such formulations provide nitrogen, potassium and phosphorus in different proportions. Either saphos phosphate (27.5 % P_2O_5) or concentrated super phosphate (42% P_2O_5) is used as the source of phosphorus and muriate of potash (60% K_2O) is included as the potassium source while the nitrogen source is either urea (46% N) or sulphate of ammonia (20.6% N). Table 11 and 12 show the composition of three fertilizer mixtures each of which could use urea or sulphate of ammonia respectively as the nitrogen source.

Urea contains a higher percentage of nitrogen than sulphate of ammonia. Therefore, the bulk and the cost of transport from the stores to the land would be less. The unit cost of urea is also much less than that of sulphate of ammonia. There are plans to produce urea locally. With the commencement of urea production, sulphate of ammonia would need to be reduced as far as possible with urea being the only available source of nitrogen. Urea is as efficient as sulphate of ammonia in the nutrition of coconut.

Table 11. Composition of urea based fertilizer mixtures (CU)

Mixture	Component of fertilizer (parts by weight)				Rate of application	
	Urea	*Saphos phosphate*	*Concentrated super phosphate*	*Muriate of potash*	*Kg.*	*Lb.*
CU 1	0.7	0.7	—	1.6	3	$6\frac{1}{2}$
CU 2	0.5	0.6	—	0.9	2	$4\frac{1}{2}$
CU 3	2.6	—	0.3	1.1	2	$4\frac{1}{2}$

Table 12. Composition of Sulphate of Ammonia based fertilizer mixture (CA)

Mixture	Composition of fertilizer (parts by weight)				Rate of application	
	Urea	*Saphos phosphate*	*Concentrated super phosphate*	*Muriate of potash*	*Kg.*	*Lb.*
CA 1	1.5	0.7	—	1.6	3	$8\frac{1}{4}$
CA 2	1.1	0.6	—	0.9	$2\frac{1}{2}$	$5\frac{1}{2}$
CA 3	1.3	—	0.3	1.1	2	6

Urea, however, has a high moisture absorbing capacity and hence fertilizer mixtures containing urea are unsuitable for storage after preparation, particularly if one of the components is concentrated super phosphate as in the mixture CU-3 (Table 11). Urea should ideally be mixed with other components only just before application. Urea stored in polythene lined bags remains stable for long periods if the bags suffer no damage and if storage conditions are good.

The fertilizer requirement of coconut has been found to differ from one region to another depending on the soil type and climate. A range of soils and soil combinations exist in different parts of Sri Lanka. As mentioned earlier, the rainfall pattern divides Sri Lanka into three major zones, *viz.* wet, intermediate and dry (see Fig. 21). Application of fertilizer should be carried out according to the soil type and climate in the areas concerned if maximum benefits are to be obtained. Fertilizer recommendations for different parts of Sri Lanka are as in Table 13.

Fertilizer Placement

The active absorbing roots of the adult coconut palm are concentrated within a zone immediately surrounding the palm up to a distance of about 1.75 metres from the bole. For maximum economy and efficiency the fertilizer should therefore be spread uniformly round the palm up to a distance of about 1.75 metres and dug over into the soil by mammoties or mammoty forks. This method of fertilizer application has been shown to be not inferior to other methods of fertilizer application that have been in use among growers, in particular, it is seen to be as effective as the more laborious circular trench system that was practised earlier. Broadcasting of fertilizer over the entire land surface has been observed to be less efficient than placement round the palm. The half circle placement of fertilizers, a once popular method, has been found to be only 40% as effective as full circle application.

On relatively steep lands which are subject to surface run-off, trench manuring is to be preferred.

Unless weed growth around the palm is excessive, fertilizer could be applied straight into the ground. The area on which the fertilizer has been applied should be lightly dug over and may be mulched with dried fronds and husks. This will also help to reduce subsequent weed growth.

Table 13. Fertilizer recommendations for different parts of Sri Lanka.

District	*Soil type*	*Fertilizer Mixture*
Colombo, Kurunegala, Kalutara, Galle, Matara, Kandy, Ratnapura, Kegalle, Chilaw, Puttalam	Lateritic loams and lateritic gravels (boralu and cabook soils)	CU 1
Chilaw, Gampaha	Cinnamon sand, costal marine sands and lagoon sandy deposits	or
Chilaw, Puttalam, Kurunegala, Hambantota, Mannar, Anuradhapura Vavuniya, Mullative, Dambulla	Deep reddish brown loams, sandy loams and clay soils	CU 2 or
Matale, Dambulla, Jaffna	Limestone derived, chocolate brown loamy soils	CA 2
Puttalam, Batticaloa, Mannar and Jaffna	Costal marine sands and lagoon sandy deposits	CU 3 or CA 3

Availability of water in the soil is essential for solubilization of the fertilizer, movement of the nutrients from the soil to the root surface and finally for absorption by the coconut palm. Thus, soil and moisture conservation measures are very important in a coconut estate to ensure that the fertilizer is most effectively used. Soil and water conservation have been discussed in chapter 10.

It is unwise to stop application of fertilizer because of a poor economic return from a plantation. This will worsen the situation and lead to further deterioration of the crop. Under adverse economic conditions, fertilizer should continue to be applied to palms annually, even at reduced rates.

Magnesium Fertilizers

Magnesium (Mg) deficiency is prevalent in certain localities particularly in the sandy and lateritic tracts of the high rainfall zones. With the application of refined artificial fertilizers, the removal of the crop and other plant parts from the plantation and the lack of use of organic manure, many coconut soils have become deficient in available magnesium. Soils that are heavily leached are more prone to magnesium deficiency. Characteristic symptoms of magnesium deficiency are general yellowing of matured fronds with the exception of a green margin on either side of petioles and the main frond axis. (see page 50). Magnesium deficiency is accentuated by excess soil acidity and the continued use of ammonium, potassium and calsium containing fertilizers. It is always easier and cheaper in the long run to take precautionary measures to avoid magnesium deficiency rather than treating for the symptoms when they have set in.

As a long term preventive measure, ground dolomitic limestone should be added to the soil on all coconut lands in high rainfall areas of the Southern and Western Provinces, at rates of 2 kg per adult palm and 1.5 kg per young palm once every three years. On lateritic gravels of the North-Western and Central Province, on the cinnamon-sand soils of the Chilaw and Negombo districts, and on light loams and sandy loams, dolomitic limestone should be applied at the rate of 1.5 kg per palm for both adult and young palms, once in three years. Dolomitic limestone is sparingly soluble in water and has 20% magnesium oxide (MgO). It releases magnesium at a very slow rate.

Where symptoms of magnesium deficiency have already set in, in addition to the long term preventive measures, kieserite should be applied at the rate of 1 kg per palm every six months for the first year and thereafter 1 kg per palm once a year until the fronds regain their normal healthy green colour.

In the case of palms showing acute deficiency symptoms, and where regular NPK fertilizers have been applied, the NPK manuring should be suspended during the first year of application of kieserite.

Use of Organic Manure

Organic manures of many origins could be used to fertilize coconut palms in Sri Lanka. Organic manures are relatively low in plant nutrients, compared to artificial fertilizers and much larger quantities are therefore required. Consequently the costs of transport and handling could also be higher. Use of organic manures should be encouraged wherever their use is possible. Sulphate of ammonia, saphos phosphate and muriate of potash equivalents of some commonly available organic manures are given in Table 14.

Cowdung can be added to provide the quota of nitrogen needed by the palm. Potassium may be added as ash derived from several organic materials such as wood, coconut husk, butt ends of fronds, paddy husk, citronella grass, Salvinia and spent cinnamon leaves etc.

Organic manure has to be supplemented with inorganic fertilizer in manuring coconut. Although most organic materials commonly available contain N, P and K complete substitution of the inorganic fertilizer with organic manure is difficult to achieve as large bulks are involved. Usually organic fertilizer requires supplementing with one or more inorganic fertilizers. In order to maintain the correct supply of major nutrient elements while using both inorganic and organic fertilizers, numerous combinations are possible. All of them could be equally effective when properly used. It is impossible to list all these combinations here, but Table 14 would help in deciding the quantities needed in each case. For further details of the use of commonly available organic manures for fertilizing coconut palms, please refer to the C.R.I. advisory leafllet No. 9 (latest edition). In home gardens particularly, the use of organic manure in fertilising coconut palms will provide a useful way of its disposal.

Composted organic residues, in addition to supplying essential nutrient elements also improve the texture, physical properties and moisture retention ability of the soil. They also create conditions favourable to the multiplication and activity of soil microbes and other forms of life useful in maintaining a biologically active and fertile soil.

Table 14. Approximate equivalent of various organic materials in terms of straight fertilizers

	(A) *Quantity of material equivalent to 1 Kg. Ammonium Sulphate*	(B) *Quantity of Saphos phosphate in the amount of material specified in column (A)*	(C) *Quantity of Muriate of Potash in the amount of material specified in column (A)*
	(K.g.)	(K.g.)	(K.g.)
Cattle dung, fresh	35	2/5	1/4
Cattle dung, dry	20	2/5	1/4
Goat dung	10	1/5	1/5
Poultry droppings—(deep litter)	20	3/5	1/3
Pig dung	30	1/2	1/5
Farmyard manure	20	1/3	2/5
Compost	35	1/2	1/4
Fish refuse and dry fish	7	3/4	traces
Salvinia weed (Fresh)	160	traces	3/4

CHAPTER 10

SOIL AND SOIL-WATER MANAGEMENT

In order to get the maximum return from the land and to ensure sustained profitable crop harvests, proper soil and water management measures should be adopted. Because practices of soil and soil-water management are often the same, these two management aspects are discussed together. Nutrients in the soil can be absorbed by plant roots only if they are in solution. Insufficient soil moisture will therefore reduce responses to the application of fertilizers.

The water in the soil is held by clay and organic matter. The higher the organic matter content in soil, the higher is its moisture holding capacity. Much of the organic matter is present in the top soil and if soil erosion is prevalent, the water holding capacity of a soil is reduced. The beating action of rain and surface run-off will loosen and dislodge the top soil unless steps are taken to minimise these risks. Continuous soil erosion finally results in barren land where nothing could be grown productively.

Rain water has to infiltrate the surface layers of earth into sub-levels in order to be stored in the sub-layers. Water conservation is achieved by allowing the maximum volume of water to be absorbed into the soil layer without allowing it to run-off the land. When water movement is properly managed on a land, soil conservation is automatically looked after as the two processes are inter-related. Soil and soil water management on coconut estates is normally achieved by adhering to the following objectives:

1. Adopting measures to prevent the loss of moisture and soil.
2. Storing as much rain water as possible by getting it to percolate into the ground and preventing run-off.
3. Conserving the available water in the soil.

Management of soil and soil-water is brought about by several practices such as:

1. Establishment of cover crops
2. Terracing
3. Mulching

4. Burying of husks in the land
5. Providing contour drains or bunds
6. Providing drains for removal of excess water
7. Contour ploughing before rains
8. Weed control

1. **Establishment of Cover Crops**

Any crop intended to prevent soil erosion is generally known as a cover crop. Cover crops are one of the most effective means of preventing loss of soil by reducing the direct impact of rain drops and the surface washing-off by rain. These crops are almost always fast-growing leguminous creepers capable of forming a profuse mat on the soil surface.

Leguminous cover crops serve a dual purpose — while reducing soil and moisture loss, they also add nitrogen to the soil. Nitrogen fixing bacteria live in the nodules of the roots of these leguminous plants and are capable of transforming atmospheric nitrogen into nitrogenous compounds which the plants can utilize. Other important benefits bestowed by a cover crop are the addition of organic matter to the soil as the crop dies or is periodically ploughed in and the prevention of weed growth.

Cover crops are recommended in high rainfall areas of the Wet Zone, particularly in sloping or undulating lands. In the low rainfall areas such as in the Dry Zone, cover crops may in addition act as a mulch once they are established. During the initial period of establishment, they may compete with coconut for moisture. Once established some cover crops die back during drought but regenerate after rains, thus minimising moisture competition with coconut. Cover crops could be grown in coconut lands until the coconuts are about three years old.

Types of Cover Crops

Three legumes have been recommended by the Coconut Research Institute for cultivation in coconut lands, namely, *Calopogonium muconoides*, *Centrosema pubescens* and *Pueraria phaseoloides*.

1. *Calopogonium muconoides* (or Calopo) is a quick growing creeper thriving in a wide range of soil types and forming a good cover in 6 - 8 months when sown under suitable

weather conditions. This cover crop favours moist conditions and it dies back in dry weather after the production of seeds. When the rains return, the seeds germinate and a fresh cover is initiated.

2. *Pueraria phaseoloides* (or Puero) is a strong twining herb much resembling *Calopogonium* in appearance. It has long leaves and it produces roots at the nodes profusely. *Pueraria* is less susceptible to insect attack but sometimes shows poor germination. This is propagated by cuttings. The rate of growth is moderate and it takes about 1½ years to form a good cover. Though it tends to die back in dry weather, after a few showers, it recovers well.

3. *Centrosema pubescens* (or Centro) is a hardier cover crop, able to withstand dry weather conditions better than *Calopogonium*. *Centrosema* does not die back in dry weather and will still persist after seeding. Even if it dies back under adverse conditions, it regenerates itself once the weather becomes favourable. This is a twining plant and it ascends any available support. Particularly, the foliage of young coconut palms should be kept clean of this cover crop. This cover crop is considered to be the most suitable for coconut soils under general conditions. A mixture of *Centrosema* and *Calopogonium* — 613.4 and 9.0 kg of seeds per ha respectively has proved to provide a good lasting cover.

Planting of Cover Crops

It is important to prepare the ground by free from weeds. This may be achieved by ploughing and disc-harrowing across the ploughed furrows. A final harrowing with a chain harrow would produce an ideal bed for the seeds to germinate. Where a chain harrow is not available, levelling the disc harrowed surface with mammoty forks and hand forks is advised.

In poor soils where soil erosion has taken place, addition of a dose of phosphorus (1 - 1.5 kg of saphos phosphate per coconut square) is advocated.

Propagation of cover crops is always done at the beginning of or during, the rainy season. Seeds, cuttings or seedlings are used in the propagation.

Centrosema seeds have a thick seed coat and their germination takes place more readily when soaked in water overnight. The soaked seeds are sown preferably at the beginning of the rains. After sowing, the seeds should be covered by lightly forking using mammoty forks, rakes or by chain harrows. *Pueraria* can be propagated more readily from cuttings than from the seeds.

Figure 14 shows a well managed cover crop in a coconut land.

When the cover crops are grown to the required level, they need to be properly managed. Allowing the cover crop to grow rank and leaving it unattended for several years would prove to be more of a disadvantage than a benefit. Light harrowing should be done once or twice a year if the cover is thick. Ploughing in of the cover crop will increase the humus content of soil. A thick cover should be disc-harrowed before ploughing in. Digging of cover crop into the soil is possible although rather laborious. Disc-harrowing facilitates the digging over operations. The cover crop may be envelope forked or grazed by cattle periodically. (*Centrosema* is readily eaten by cattle while *Calopogonium* and *Pueraria* are relished to a lesser extent by them.

Ploughing should be carried out during the rainy weather. The rains will ensure the regeneration of the treated crop either by seed or the fragments produced during the treatment. It is advisable to leave alternate rows undisturbed as a precautionary measure against the complete extinction of the crop from the land should unfavourable conditions prevail after the treatment. Such management can be especially helpful in the case of *Pueraria* which is often slow in recovery. On hilly lands the alternate strips should be selected along the contours.

2. **Terracing**

Surface run-off is intercepted and allowed to be absorbed by the soil around the palms by terracing. The tendency for soil to get washed away increases with the undulating nature and steepness of the land. In sloping lands where the gradient exceeds about 1 in 7, the palms should be terraced. Terraces are best made of stones where available. The stones are arranged round the base of the palm in a circle of radius 2.5 - 3.0 metres and the soil is built around the inside of the terrace. Where stones are not available, an earth bank can be built around the palm. In such a case, the earth bank should be turfed with a cover grass such as carpet grass or *Paspalum* grass. The inside banks of the terrace should be sloped into the hills so that the surface run-off is ponded back into the base of the palm allowing washed off soil to deposit and the water to get absorbed. This procedure also prevents formation of a fast water flow down-hill which could remove nutrients and top soil.

Fig. 14. Well managed cover crop in a coconut land.

Fig. 15. Contour drains in a coconut land.

3. **Providing Mulches**

Mulch is a common term used to refer to a layer of leaves of similar material spread over the ground to prevent drying out. Among materials that could be used as a mulch are coconut fronds, fallen leaves of trees etc. Out of these, husks are the most easily and freely available material for the coconut grower to use as mulch.

Use of Husks as a Mulch

In districts where fibre milling is not practised, coconut husks often accumulate and their proper disposal may present a problem to the coconut growers. The husks in such situations would provide a readily available raw material to be used in the estate in the conservation of moisture, prevention of erosion and to improve and reserve soil fertility.

Mulching with coconut husks can be done in two ways:

1. Mulching round the base of the palms.
2. Broadcasting husks between palms.

Mulching Round the Base of Palms

This method is often followed in coconut estates in Sri Lanka. A layer of coconut husks is laid around the base of the palm with the fibrous side of the husk facing downwards from about 0.3 m. from the base of the palm, upto a distance of about 1.8 to 2.1 m.

This form of mulching around the base is particularly effective in gravelly soil during the dry season. Further, the husk mulch smothers the growth of weeds which are a nuisance particularly after the application of fertilizers. Husk mulches round the base are especially beneficial for young palms growing under low-rainfall conditions. If this method of mulching is practised on loose sandy soils, the husks should be removed with the commencement of the rainy season to prevent formation of a surface mat of roots.

Broadcasting Husks Between Palms

This method of mulching with husks is not recommended as a rule except when the husks cannot be otherwise disposed of. Broadcasting husks has given good results in gravelly and lateritic soils which usually suffer most during droughts. If the burying of husks in trenches (see below) is not possible owing to high labour cost, husks can be successfully utilized by broadcasting. Husks decay sooner when broadcast than when buried (see below).

Two years after broadcasting, the husks are partially decayed. In order to avoid surface rooting it is advisable to plough in these partially decayed husks. Broadcasting of husks in sandy cinnamon soils is not recommended.

4. **Burying of Husks in the Land**

It is always wise to return the husks back to the soil rather than disposing of them. In fact, husks buried in trenches can effectively reduce the drastic effects brought about by droughts. Such benefits are common in estates in the North-Western Province of Sri Lanka during droughts. Husk burying is also helpful in reducing premature nut-fall which is associated with drought (see page 118). Husk burying can be carried out in all soil types although the practice is particularly useful in gravelly and sandy soils. However this practice is not suitable for water-logged soils with poor drainage.

Husk burying can bring about other advantages such as the return of nutrients to the soil, thereby reducing fertilizer requirements. Husks are particularly rich in potassium which is present in the husks in a highly soluble and easily available form. About 100,000 husks contain potassium equivalent to 1 ton of muriate of potash.

Burying of husks in coconut lands can be carried out in several ways. Three such methods are given below :

a. Burying of husks in the centre of four palms.

b. Burying of husks between rows of palms.

c. Burying of husks in trenches along rows of palms.

The husks are buried layer by layer and each layer is covered with layer of earth. Systematic packing of husks is not needed as this would not result in any extra benefit. The last layer is made flush with the ground and the excess soil is piled on top of the buried husks.

(*a*) **Burying of Husks in the Centre of Four Palms**

Husk buried in this manner can be in square pits (1.2 m × 1.2 m × 1 m) or in circular pits. (1.8 metre diameter 30 cm deep). This system has the disadvantage that the husk pit is situated more than 4.5 metres away from the base of the palm. Having a husk pit in the centre can also affect the use of cultivation implements such as ploughs and harrows. No intercrops can be planted under this system.

(*b*) **Burying of Husks Between the Palm Rows**

In this process, trenches, about 2.5 to 3 metres wide are cut and husks are buried. The trenches are made along the whole length between the rows of palms (long line trances). In this method, a large amount of husks are consumed and the operation of farm implements may be hindered as a result.

(*c*) **Burying of Husks Along Rows of Palms**

This is a popular and is a preferred method over the two methods previously mentioned. The husks are buried in trenches of the dimensions, 3 metres long, 1.2 metres broad and 0.5 metres deep arranged alternately along the rows of coconut palms. Such a trench would hold anywhere between 250-500 husks depending on nut size. In sloping lands, these pits should be arranged along the contours. Fig. 16 indicates the ground plan of the arrangement of husk pits along palm rows in a coconut estate. When the husks are to be buried in the same land again, trenches can be dug in alternate positions.

Cover crops and/or green manure such as Boga or *Crotolaria* can be readily grown on the top of the husk pits.

5. **Providing Contour Drains or Bunds**

Contour drains should be provided in sloping lands where the surface layer is hard and poorly permeable to water. Contour drains and bunds are dug along the contours on the slope (see figure 15). The drains should be about 60 cm deep and the distance between adjacent drains depends on the steepness of the slope. Contour bunds can be made wherever possible with stone walls. The run-off water carrying the eroded surface soils along the slope gets collected in the contour drains or behind the contour bunds.

There are divergent notions on whether the excavated soil should be thrown above or below the drain. The former is perhaps more logical.

6. **Providing Drains for Removal of Excess Water**

The idea of providing these drains is to allow the escape of excess rainwater without stagnating in the land to cause inadequate aeration for the plant roots. A system of drains with a maximum drop of one metre for 120 metres should be made to take excess water away from the land. This system may

be connected and joined with the nearest natural water drainage channel. Regular maintenance of drains is necessary (see CRI Advisory Leaflet No. 16).

7. **Contour Ploughing** (Before rains)

Contour ploughing can help the infiltration of rain water into the deep layers of the soil. Ploughing is done along the contour lines, against the slope of the land. Ploughing breaks up the surface layer which is poorly permeable to water and make it more absorptive causing a large quantity of water to infiltrate into the layers below.

8. **Suppression of Weed Growth**

A substantial quantity of water is lost through transpiration by weeds. The need for regular control of weeds in coconut lands particularly in the Dry and Intermediate rainfall zones cannot be over-emphasized. A detailed discussion on this aspect appears in Chapter 11.

9. **Other Water Management Practices**

Water management measures discussed above particularly referred to the well drained soils in low rainfall areas. Management practices dealt with in this section specially refer to the poorly drained water logged soils. Such coconut lands are seen in many parts of Sri Lanka, *e.g.*, around Chilaw, Madampe and Katunayake. Coconut trees growing in conditions of water logging show poor canopy formation thin, tall trunks often tapering at the top, and no appreciable crop return. Palms often resemble drought-affected ones because there are insufficient active roots to absorb water, though water is plentiful. Such lands can be improved to a large extent with wisely implemented soil and water management practices.

The following two steps are helpful in achieving this.

a. Soil building around the base of palms.

b. Making permanent drainage drains.

(*a*) **Soil Building Around the Base of Palms**

Under water logged conditions, roots produced die prematurely due to the deficiency of oxygen in the soil thus reducing absorptive area available. Building of soil around the base of the palms can improve conditions

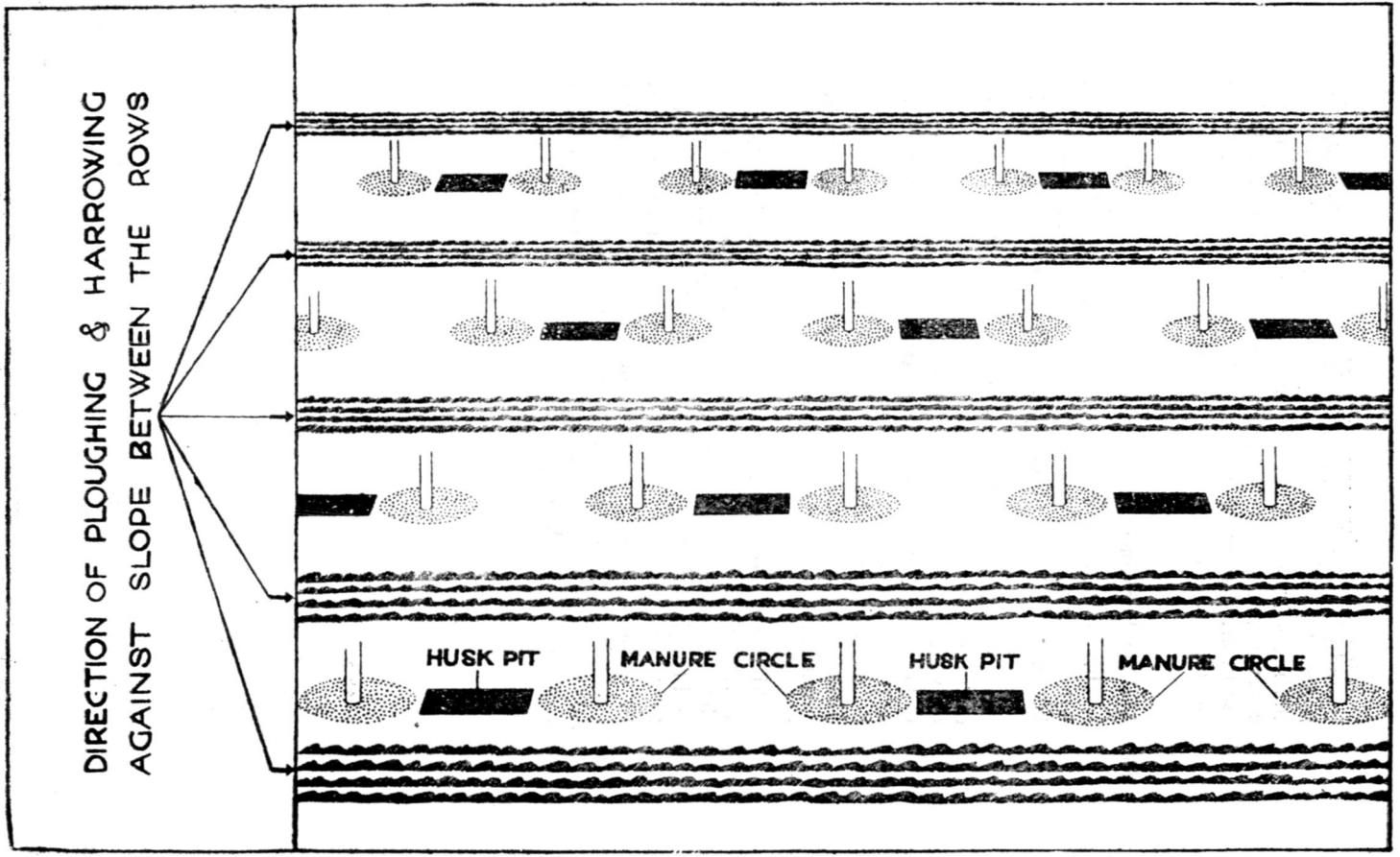


Fig. 16. Ground palm of the arrangement of husk pits

by inducing the formation of fresh roots at the bole (see figure 19). These roots are healthy and live longer than the roots below. Coconut husk can prove useful in the construction of the soil platforms. The fibrous husks are inverted round the base of the palm and covered with silt removed from the drains (see below).

(*b*) Making Permanent Drainage Drains

This is a measure to be followed particularly in lands with severe water-logging. Permanent drains are cut between all rows of coconut palms. The earth or silt removed is used to raise the ground level of the square 'Island' on which the coconut palms will stand. The depth of the drains would be according to the severity of water-logging. Regular maintenance of these drains is necessary. Though the construction and maintenance of platforms and drains are costly operations, they produce excellent results. Burying of husks in soil or placing of husks in planting holes in such soils could aggravate the situation.

Measures to permanently prevent water-logging are worth looking at. Water logging conditions arise due to the high content of clay in the soil and poor drainage that is brought about as a result. Sometimes, it is possible to prevent water-logging in a given area if the cause is identified correctly. One of the causes of water-logging could be a stream or drainage drain ending blindly. In such a situation the water-way should be diverted away from the water-logging area.

CHAPTER 11

WEED CONTROL

Weeds are the biggest competitor with coconut palms for nutrients and water. In dry poor soils, weeds in the coconut land may bring about serious problems and proper control of weeds important.

Important weeds in coconut lands in Sri Lanka are *Chromolaena odorata* (earlier *Eupatorium odoratam* or Podisingho maran), *Imperata cylindrica* (Illuk) and *Pennisetum polystachyon* (Mana), *Mimose pudica* (Nidikumba) (see Figures 17 to 20). Less common weeds are *Cenchrus echinatus* (Kuweni), *Sida acuta* (Gasbebila), *Hedyotis auricularia* (getakola), *Vernonia cinerea* (Monarakudumbiya) and *Hibiscus*.

If complete eradication of weeds is not possible, at least measures should be taken to suppress them. Important methods used in control and suppression of weeds are as follows :

1. Soil cultivation
2. Mowing and slashing
3. Use of cover crops
4. Grazing
5. Herbicide use

1. Soil Cultivation Methods

Soil cultivation methods include mammoty weeding of weeds, ploughing and harrowing.

(*a*) Mammoty Weeding

Mammoty weeding is the most effective and easy method of suppressing weeds with underground stolons. In the control of the weed *Imperata cylindrica* (Illuk) and *Chromolaena oderata* two of the most troublesome weeds in coconut estates, manual digging is the only practical way of successful eradication. This procedure however is labour demanding.

(*b*) Harrowing and Ploughing

Harrowing and Ploughing are helpful in suppressing most of the weeds except illuk and *Chromolaena*, as they have the ability to regenerate vegetatively from their slips and cuttings unless they are gathered and burnt after these. Harrowing is usually done in coconut estates before the flowering of weeds so as to prevent the seed propagation.

2. Mowing or Slashing

This is a measure for suppressing weeds. By mowing or slashing*, the aerial parts of the weeds are removed, thereby cutting off the food supply to underground stems. Repeated slashing could bring about the death of the weed ultimately. The cut leafy tops act as a useful mulch on the ground conserving moisture. Removal of leaf also reduces water loss through transpiration by the weed leaves. Mowing may not be as easy as slashing where portions of the land are cultivated with other crops. Slashing done at sufficient frequency is capable of keeping the growth of ordinary weeds down at an acceptable level. However, slashing is also a labour intensive operation.

3. Use of Cover Crops

Weeds that do not tolerate shade and competition by other faster growing species could be suppressed effectively by introducing suitable cover crops. Cover crops grown for weed suppression are also frequently legumes which are beneficial as they add nitrogen to the soil.

The cover crops *Tephrosia candida* (Bogamedilla), Cowpea, or green gram can be grown effectively as suppressors for weeds in coconut lands. Bogamedilla is effective only if introduced when the weed is just germinating. The effect of the cover crops and their establishment is limited if weed has been allowed to grow before the cover crops establishes itself. In the case of the weed *Chromolaena*, the cover crop, *Tephrosia purpurea* (Pila) has been found to be a successful suppressor. The defoliating insect *Ammalo insulata* (Lepidoptera) has been introduced by the Coconut Research Institute as a control agent of *Chromolaena*. Its establishment at present is restricted to certain areas of Sri Lanka.

* Slash is a sharp blade about 3 cm broad and 20 cm long fitted at a right angle to a long pole. Tops of weeds are removed by rapidly swinging the slash side-ways.

Fig. 17. Chromolaena odorata (Podisingho maran) *weed in a coconut plantation.*

Fig. 18. Imperata cylindrica (Illuk) *weed.*

Fig. 19. Pennisetum polystachyon (Mana) *weed.*

Fig. 20. Mimose pudica (Nidikumba) *weed in a coconut land.*

4. **Grazing**

Grazing wherever possible is a good way of controlling weeds. In place of human labour, animals are utilized in this act. Unfortunately, however, all weeds are not relished by cattle or goats. Probably owing to its strong smell, cattle do not feed on *Chromolaena*. Illuk growth can be economically checked at the young stage by allowing cattle and buffaloes to graze it. The weed Kuweni is also relished by cattle prior to the flowering stage.

5. **Herbicide Use**

Herbicides (or Weed-killers) are chemicals capable of destroying plants selectively. Use of herbicides bring about the most effective control of many weeds in coconut lands. Several formulations of weed killers are available from producers and dealers in agricultural chemicals. However, as far as possible, the use of chemicals such as weed-killers should be avoided if other control measures are feasible. Protracted and injudicious use of herbicides have been known to create problems by encouraging the growth of weeds even more troublesome than the species eradicated. They could also result in other forms of environmental deterioration.

CHAPTER 12

INTERCROPPING UNDER COCONUT, PART I GROWING FIELD CROPS

With the pressure an arable land increasing rapidly, intercropping of coconut lands represent a practice of great importance and promise. Unfortunately paucity of reliable information in the economic and agronomic aspects. Most coconut growing soils in the different agroclimatic zones of Sri Lanka are suitable for growing certain food crops and pastures which could increase returns from the land.

Intercrops can exert pressure on the main crop coconut, but their effects can be much reduced if there is adequate moisture in the soils and if fertilizer is applied regularly as recommended for both coconut and the intercrops and if the plantation is managed properly.

Of the major plantation crops of Sri Lanka, tea, rubber and coconut, it is true to say that coconut bring in the lowest return (Rs. 625/- per ha per annum), compared to tea (at Rs. 3500/- per ha per annum) or rubber (Rs. 1500/- per ha per annum). Compared to rubber or tea however, coconut plantations offer a large area that could be used for growing other profitable crops. In "square planting" of coconut (7.9 m × 7.9 m), up to about five years, approximately 69 per cent of land will be available for intercropping while in a mature stand, about 54 per cent of land will be available. The combined income from coconuts and intercropping and/or animal husbandry would almost reach the income from tea if not actually surpass it. Generally, the labour requirement in a coconut estate is the lowest out of the three major plantation crops of Sri Lanka being about 1 labourer for 4 ha. The labour requirement for intercropping is likewise more and varies with the type of intercrop. Upto one extra labourer for each ha of coconut under intercropping could be employed. This intercropping has high social benefits as well. The standard square system of coconut planting allows a growing intercrops for a period of 35 - 40 years successfully torwards the end of its life span. In plantations with adult palms of 20 yr or more permanent crops such as coffee, cocoa, pepper; semi-permanent crops such as plantain, pineapple and short term crops such as manioc, sweet potatoes,

millets and pulses can be grown depending on the rainfall and the type of soil. Under young palms of age less than four years only the semi-permanent and short term crops can be grown. To obtain the most beneficial results, a proper understanding of the ecology of the intercropping system is necessary.

Ecological Aspects of Intercropping

Intercropping under coconut changes the habitate of the coconut palms from a monoculture situation. Some of the effects are beneficial while others are disadvantageous. With correct understanding, the disadvantages of inter-cropping can be avoided and the advantages enhanced. Intercrops and coconut interact with one another as they share requirement factors involved in the interactions are light, soil moisture and nutrients.

Light

Success in establishing an intercrop depends on the amount of light that is able to penetrate the canopies of the coconut palms. It is evident that during certain stages of growth, the coconut palms does not allow sufficient light in for the establishment of an intercrop in a standard square planting system. In a triangular or closer planting system it is seldom that intercrops could be established successfully owing to the inadequate light penetrating the canopies. While in a square planting of coconut at standard distances apart, crops can be grown until the palms are about four years of age, the light available for crops under coconut palms from 5 years upto about 20 years is not adequate for plant growth. From 20 years on, the land progressively become suitable again for growing intercrops as sufficient light will fall at intensities and for durations high enough for the growth of many inter-crops. In older coconut stands the intensity of light on the plantation floor can be more than 80 per cent.

Light intensity during the day also varies. In a thirty-year old plantation, the intensity of light during noon is about 60 per cent of the normal light intensity. The intensity early morning and the late afternoon is about 50 per cent that in the open.

The amount of light available for the intercrops largely dictates the type of intercrop that could be grown. A good indication as to the suitability of a coconut land for the establishment of intercrops is the presence of a herbaceous grass and weed cover. Among intercrops, shade tolerances also can differ.

Soil Moisture

The moisture requirement of the coconut palm itself is very high and is one of the important factors governing the production of nuts. Although there is generally no competition for moisture during the rainy season, such competition can appear and increase during dry periods. Transpiration through leaves is necessary for healthy growth as it brings about cooling of the leaves during hot weather. The process also transports water and nutrients to the top of the plant for the synthesis of organic food materials. A volume of 28-45 litres of water is estimated transpired by a coconut crown on a normal sunny day, with each leaflet transpiring about 11g of water. If in the dry season the absorption of water is insufficient to balance this loss, it will limit the movement of nutrients into the leaves. Certain intercrops are known to compete heavily with coconut for moisture.

Experiments have revealed that in the areas receiving rainfall of 190 cm or more annually, there is no apparent competition ideally suited for many other intercrops as well. In order to ensure that the coconut crop is not constrained, surface irrigation and mulching operations should be carried out for the intercrop during dry weather.

Nutrients

It has to be appreciated by the grower that growing intercrops, results in competition for nutrients by coconut and intercrop. Nutrients particularly nitrogen, phosphorus and potassium are vital for the general nutrition of coconut as well as the intercrop. As pointed out elsewhere, high income from coconut can only be obtained when adequate fertilizer is applied regularly. Growing intercrops with too little attention for fertiling will cause deterioration or both crops resulting in disappointments and failures. Fertilizing of coconut palms should be done as shown on page 52 irrespective of whether there is an intercrop. The intercrops should be in turn be fertilized independently as recommended for the particular crop.

Application of fertilizer to intercrops indirectly improves coconut yields as the coconut roots outside the manure circle also can tap some of the nutrients added to the intercrop. Leguminous intercrops such as cowpea, ground nut, green gram, black gram etc., improve the nitrogen status of the soil. Many intercrops reduce soil erosion and hence nutrients in the soil are protected during heavy rains. Growing intercrops such as ground nut for instance can effectively suppress the growth of weeds which compete with coconut.

Factors Governing the Choice and Cultivation of Intercrops

The major factors governing the suitability of intercrops in any part of Sri Lanka are the climate, the nature of the soil, terrain of the land, shade tolerance of the intercrops, and the economic aspects including marketing, processing and storage.

Climate, Soil Type and Terrain

Rainfall is the most critical factor affecting the choice of intercrops under coconut. The nature of crops that could be grown in the three climatic zones, Wet, Intermediate and Dry should match the distribution of rainfall (Fig 61). Within each rainfall zone, the type of crops that could be grown best are decided, on the soil types of the area and the terrain. Thus different areas of Sri Lanka offer different agro-ecological conditions for crops. Fig. 21 shows the Agro-ecological divisions of Sri Lanka. The expected rainfall, drought, the soil groups and the terrain of the above zones are summarized in Fig. 22. Coconut is successfully grown in eleven agro-ecological regions in Sri Lanka described as WL_1, WL_2, WL_3, WL_4, IL_1, IL_2, IL_3, DL_1, DL_2, DL_3, and DL_4.

It is important to select intercrops to suit the terrain of the coconut land. In sloping lands, permanent or semi-permanent intercrops could be grown while paying careful attention to the prevention of soil erosion. Those intercrops which need frequent loosening of soil around them should be avoided on slopes.

Shade

Intercrops should be positioned correctly within the estate to get the optimum benefit from the available sunlight. In areas receiving relatively less light, shade tolerant intercrops such as yams (*e.g.* colocasia, dioscorea yams), coffee, cocoa, pepper, ginger and turmeric could be grown.

Marketing and Disposal

All intercrops are grown anticipating a satisfactory financial return. Crops for which there is a high consumer demand, such as chillies, pulses, yams and vegetables are preferred where possible. Minor export crops such as coffee, cocoa, pepper, cardamom,

cinnamon all of which fetch a very good price could be intercropped with great economic advantage. Intercrops producing perishable fruits or crops which do not tolerate extensive transportation and handling should be best grown close to markets or processing centres.

Labour Requirements

As pointed out, intercropping is socially welcome as it can provide employment to more persons. However, when planning an intercrop to be grown in a particular area, the availability of labour should be given consideration. Crops such as chillies, manioc and turmeric are comparatively more labour demanding. Unavailability of labour for weeding, harvesting etc. at the required time may result in financial and crop losses. Hence the need for careful consideration of this aspect.

Pest and Diseases Common to Coconut and Intercrop

Intercrops should be chosen so that pests and diseases of the intercrops would not harm or damage the coconut crop or *vice versa*. For instance, in an area where coconut trees are affected by rats or porcupines (see page 99) growing of intercrops such as groundnuts, or yams could worsen the pest situation. If cocoa is grown under coconut affected with bud-rot disease (see page 104) the pod-rot disease in cocoa may set in as the same fungus is responsible. Thus consideration should be given to this aspect too before deciding on the type of intercrop.

INTERCROPPING PROGRAMMES UNDER COCONUT FOR SRI LANKA

For the purpose of drawing up an intercropping programme for the country, the coconut growing areas (see Fig. 22) are classified into the following groups:-

Group I Areas falling within the Agro-ecological regions WL_1, WL_2, WL_3, and WL_4

Group II Areas falling within the regions IL_1 and IL_2

Group III Areas falling within the regions IL_3, DL_1, DL_2, DL_3 and DL_4

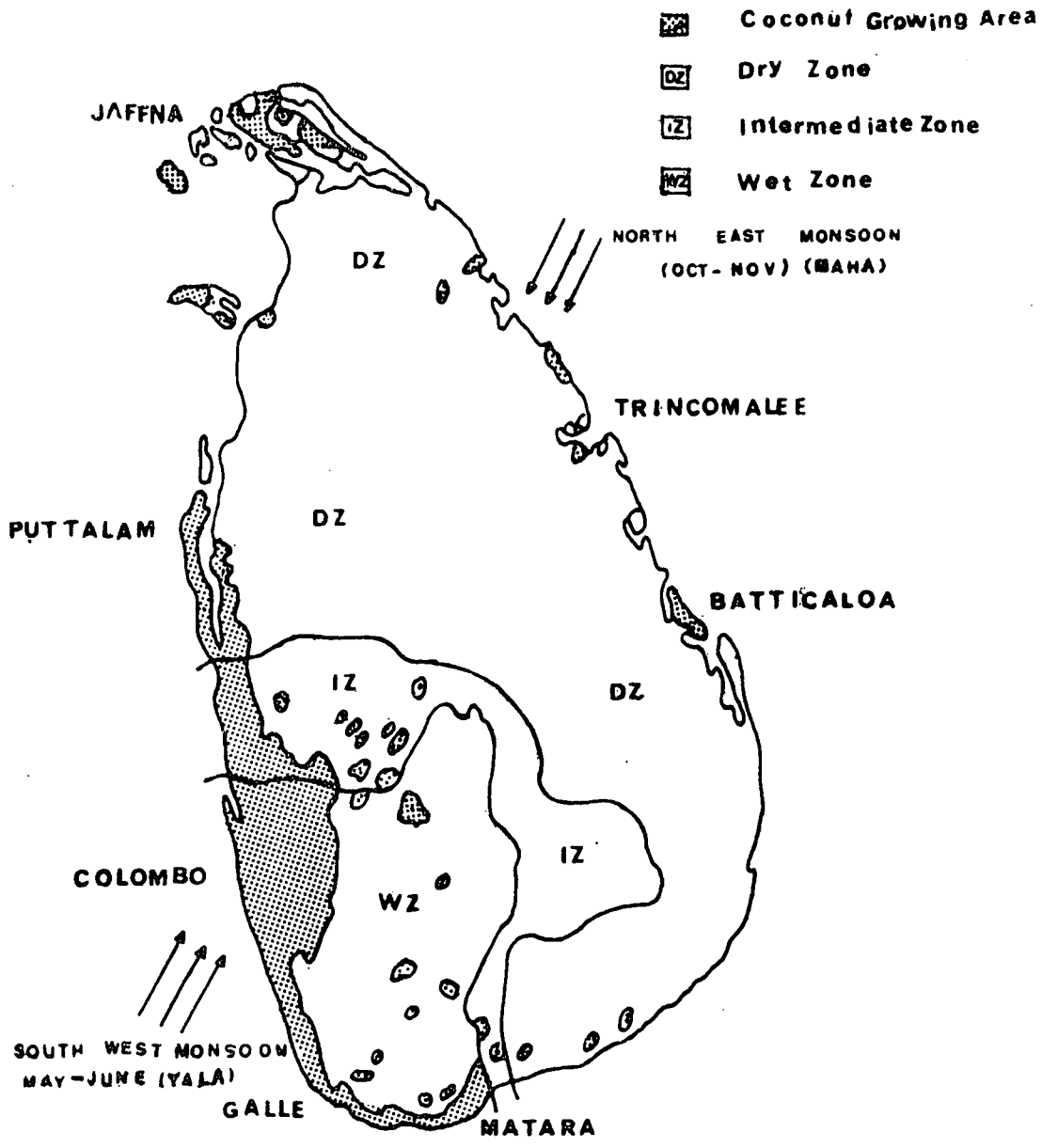
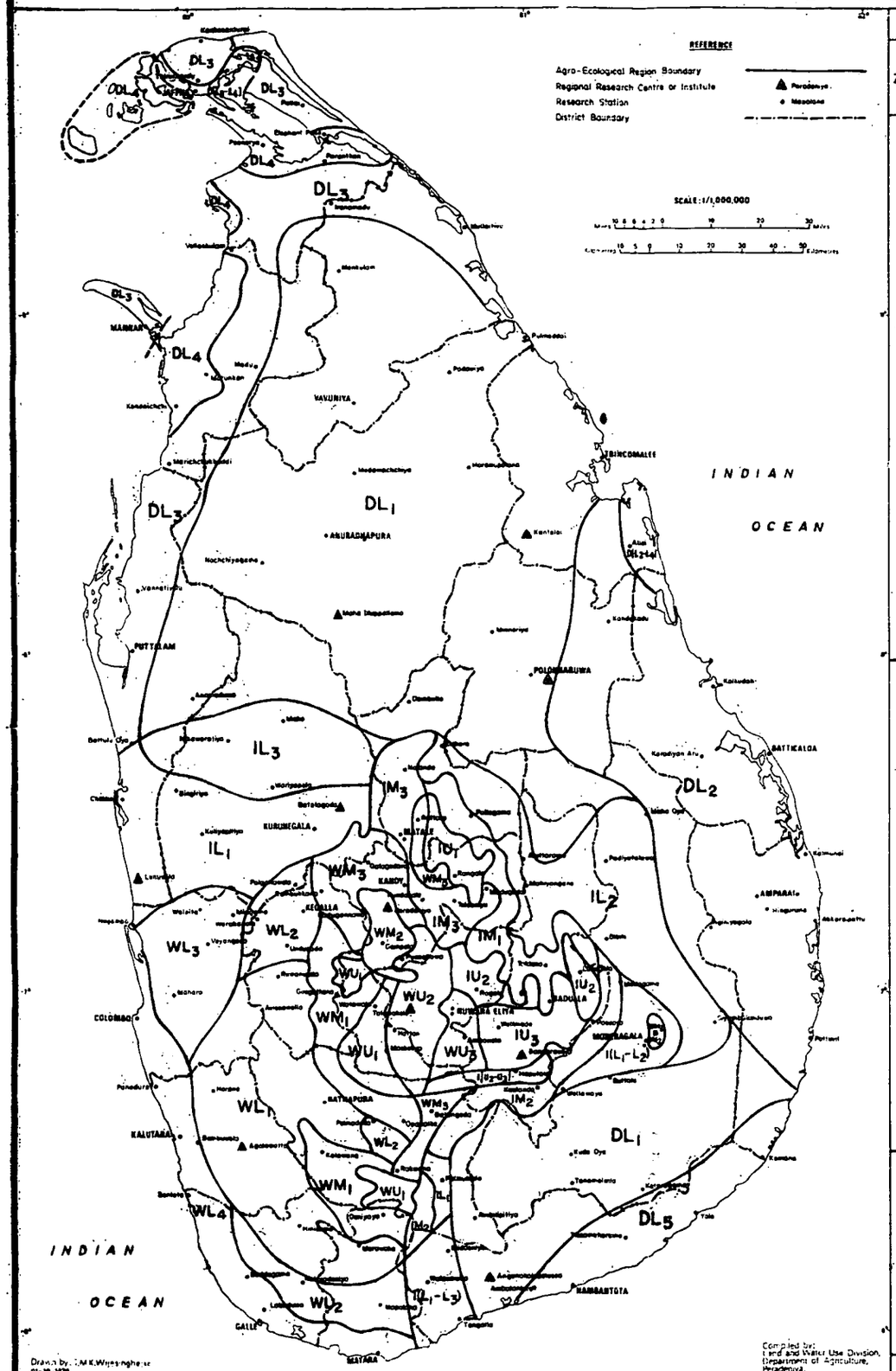


Fig. 21. Agro-ecological divisions of coconut growing areas in Sri Lanka.

AGRO ECOLOGICAL REGIONS OF SRI LANKA



DISTINGUISHING CHARACTERISTICS

ZONE	AGRO-ECOLOGICAL REGION & SYMBOL		MONTHLY HISTOGRAMS of 75% RAINFALL PROBABILITY for RESPECTIVE REGIONS	75% EXPECTANCY VALUE of ANNUAL RAINFALL (ins.)	75% EXPECTANCY OF DRYNESS for PARTICULAR MONTHS	MAJOR SOIL GROUPS	TERRAIN
					JAN FEB MAR MAY JUN JUL AUG SEP		
WET ZONE	UP COUNTRY	WU_1		> 125	J½ F • • • • • •	Red - Yellow Podzolic soils and Mountain Regosols.	Mountainous, steeply dissected hilly and rolling
		WU_2		> 75	J½ F ½M • • • • •	Red - Yellow Podzolic soils and Mountain Regosols.	Mountainous, steeply dissected hilly and rolling.
		WU_3		> 55	J½ F ½M • • • • •	Red - Yellow Podzolic soils with dark B horizon; and Red - Yellow Podzolic soils with prominent A_1 horizon	Rolling
	MID COUNTRY	WM_1		> 125	J½ F • • • • • •	Red - Yellow Podzolic soils; and Red - Yellow Podzolic soils with semi-prominent A_1 horizon	Steeply dissected, hilly and rolling
		WM_2		> 55	J½ F ½M • • • • •	Reddish Brown Latosolic soils, Immature Brown Loams; and Red - Yellow Podzolic soils.	Steeply dissected, hilly and rolling
		WM_3		> 50	J½ F ½M • • • Aug½ •	Reddish Brown Latosolic soils, Immature Brown Loams; and Red - Yellow Podzolic soils.	Steeply dissected, hilly, rolling and undulating
	LOW COUNTRY	WL_1		> 100	J½ F • • • • • •	Red - Yellow Podzolic soils and Red - Yellow Podzolic soils with semi-prominent A_1 horizon	Rolling and undulating
		WL_2		> 75	J F • • • • • •	Red - Yellow Podzolic soils, Red - Yellow Podzolic soils with strongly mottled sub soil, and Low Humic Clay soils.	Rolling and undulating
		$WL_{3\&4}$		> 60	J F ½M • • • Aug •	WL_3 — Red-Yellow Podzolic soils with soft and hard laterite WL_4 — Red-Yellow Podzolic soils with soft and hard laterite; and Bog and half Bog soils.	WL_3 — Rolling and undulating WL_4 — Undulating and flat
INTERMEDIATE ZONE	UP COUNTRY	IU_1		> 85	• • ½M • • Jul½ Aug ½Sep	Red - Yellow Podzolic soils and Mountain Regosols	Mountainous, steeply dissected, hilly and rolling
		IU_2		> 55	• F½ ½M My½ Jun Jul Aug Sep	Red - Yellow Podzolic soils and Mountain Regosols.	Mountainous, steeply dissected, hilly and rolling
		IU_3		> 45	• F ½M • Jun Jul Aug ½Sep	Red - Yellow Podzolic soils.	Steeply dissected, hilly and rolling
	MID COUNTRY	IM_1		> 55	• • M My½ Jun Jul Aug ½Sep	Reddish Brown Earths and Immature Brown Loams	Rolling, hilly and steep
		IM_2		> 45	J½ F • • Jun Jul Aug Sep	Reddish Brown Earths and Immature Brown Loams.	Rolling, hilly and steep
		IM_3		> 35	• F M My½ Jun Jul Aug Sep	Immature Brown Loams, Reddish Brown Latosolic soils; and Reddish Brown Earths.	Steeply dissected, hilly and rolling
	LOW COUNTRY	IL_1		> 40	J F ½M • • Jul Aug ½Sep	Red - Yellow Podzolic soils with strongly mottled sub soil, Low Humic Gley soils, Red-Yellow Podzolic soils with soft and hard laterite; and Regosols on old red and yellow sands.	Rolling, undulating and flat
		IL_2		> 45	• F½ M My½ Jun Jul Aug ½Sep	Reddish Brown Earths, Immature Brown Loams and Low Humic Gley soils.	Rolling, hilly and undulating
		IL_3		> 35	J F ½M My½ Jun Jul Aug ½Sep	Reddish Brown Earths, Non Calcic Brown soils and Low Humic Gley soils.	Undulating
DRY ZONE	LOW COUNTRY	DL_1		> 30	J½ F ½M My½ Jun Jul Aug ½Sep	Reddish Brown Earths and Low Humic Gley soils	Undulating
		DL_2		> 35	• F½ M My Jun Jul Aug Sep	Non Calcic Brown soils, Reddish Brown Earths, soils on old alluvium, Solodized Solonetz, Low Humic Gley soils and Regosols.	Undulating and flat
		$DL_{3\&4}$		> 23	J½ F M My Jun Jul Aug ½Sep	DL_3 — Red-yellow Latosols and Regosols. DL_4 — Solodized Solonetz, Solonchaks and Grumosols.	DL_3 — Flat to slightly undulating DL_4 — Flat.
		DL_5		> 20	J½ F M My Jun Jul Aug ½Sep	Reddish Brown Earths with high amount of gravel in sub soil, Low Humic Gley soils and Solodized Solonetz.	Undulating and flat

• Denotes wetness for the month —— J½ – Denotes second half of January ½M – Denotes first half of March } Similarly for other months

Fig. 22. The Agro-ecological regions of Sri Lanka.

The choice of the intercrop will also depend on the soil depth and terrain. The depth of the soil and terrain appears to be more important than the type of soil which could vary considerably even within a small area. The soil and topography can be divided into four categories as follows :

a. shallow flat
b. deep flat
c. shallow sloping
d. deep sloping

Soils with a depth of less than 1 metre are considered to be shallow and lands with more than 5 per cent slope are considered sloping.

The regions (electorates are taken as convenient subdivisions of regions here) falling into each of the agro-ecological and soil groups and the recommended crops and crop combinations (crop models) for intercropping under coconut under rain-fed conditions are in order of priority as listed below. (The priority has been based on the total likely income).

1. Intercrops and crop combinations recommended (in order of priority) for growing under coconut in the Low Country of the Wet Zone (in the regions WL_1, WL_2, WL_3 and WL_4) on shallow flat land are given below.

Crops
1. Pepper
2. Passion fruit
3. Pineapple
4. Ginger
5. Turmeric
6. Cinnamon
7. Pastures
8. Yams and tubers

Crop combinations
1. Pineapple and pepper
2. Pasture and pepper
3. Pepper on coconut and any of the listed crops as suitable.

Electorates — Bandaragama, Galle, Habaraduwa, Ja-ela, Katana, Kelaniya, Kesbewa, Kolonnawa, and Kotte.

2. Intercrops and crop combinations recommended (in order of priority) for the Low Country Wet Zone (WL_1, WL_2, WL_3 and WL_4) on shallow sloping land are as follows:-

Crops
1. Pepper
2. Cinnamon
3. Pineapple
4. Passion fruit
5. Pastures

Crop combinations
1. Pineapple and pepper
2. Pasture and pepper
3. Pepper on coconut and any of the listed crops as suitable.

Electorates — Akmeemana, Harispattuwa, Ambalangoda, Attanagalla, Avissawella, Baddegama, Balapitiya, Bentara-Elpitiya, Beruwala, Biyagama, Divulapitiya, Dompe, Gampaha, Habaraduwa, Homagama, Horana, Kaduwela, Kalutara, Kamburupitiya, Karandeniya, Mahara, Maharagama, Matugama, Minuwangoda, Mirigama and Ratgama.

3. The following intercrops and crop combinations are recommended (in order of priority) for the Low Country Wet Zone (WL_1, WL_2, WL_3 and WL_4) on deep flat and deep sloping land.

Crops
1. Cocoa
2. Coffee
3. Pepper
4. Cloves
5. Banana
6. Nutmeg

Crop combinations
1. Coffee at 2.4 m × 3.1 m two rows with one row of pepper in the middle.
2. Pepper on coconut with any of the crops listed as suitable.

Electorates—Dedigama, Devinuwara, Dodangaslanda, Galagedera, Galigomuwa, Harispattuwa, Hewaheta, Kegalle, Kundasale, Matale, Matara, Mawanella, Mawatagama, Moratuwa, Panadura, Polgahawela, Rambukkana, Teldeniya and Weligama.

4. Crops and crop combinations suitable for intercropping (in order of priority) in the Low Country Intermediate Zone (IL_1 and IL_2) with shallow flat land are given below.

Crops
1. Pineapple
2. Pastures
3. Manioc
4. Papaw
5. Cereals and pulses (for older and new plantations only. Can be grown both during Yala and Maha).

Crop combinations
1. Pineapple and papaw
2. Pineapple and Manioc

Electorates — Beliatta, Dambadeniya, Katugampola and Kuliyapitiya.

5. Crops (in order of priority) that can be intercropped under coconut on the deep flat lands of the Low Country Intermediate Zone are as given below.

Crops
1. Manioc
2. Papaw
3. Banana in favourable localities
4. Chillies and vegetables
5. Pastures
6. Cereals and pulses (in older and new plantations can be grown both during Yala and Maha).

Electorates — Bingiriya, Chilaw, Nattandiya, Panduwasnuwara, Wennappuwa.

6. The following intercrops (in order of priority) could be grown on the deep sloping lands in the Low Country Intermediate Zone.

Crops
1. Papaw
2. Banana in favourable localities
3. Citrus fruits
4. Pastures

Electorates — Bibile, Kurunegala, Moneragala and Mulkirigala.

7. The following list indicates the recommended intercropping priorities for the deep flat lands in the Low Country Dry Zone and in the deep flat lands in the Low Country Intermediate Zone.

Crops
1. Chillies, onions and vegetables
2. Cereals and pulses
3. Manioc

Electorates — Anamaduwa, Batticaloa, Chavakachcheri, Kalkudah, Kalmunai, Kayts, Kilinochchi, Mannar, Mullaitivu, Mutur, Nikaweratiya, Padirippu, Pothuvil, Puttalam, Samanthurai, Tangalle, Tissamaharama, Wariyapola and Wellawaya.

Figures 23, 24, 25, 26, 27 and 28 depict some of the intercropping possibilities that could successfully be carried out under coconut, namely, pineapple, cowpea, turmeric, chillies, coffee cocoa and passion fruit respectively. Pasture production and animal husbandry under coconut has been separately dealt with in Chapter 13.

Management of Intercropping

Where applicable, procedures mentioned in earlier chapter on manuring, soil and water conservation, weed control and estate sanitation (see Care of the Plantation, Chapter 16) should be observed in managing a coconut plantation with an intercrop as well. Another important aspect of intercropping is the rotation of intercrops. Growing intercrops particularly like manioc and plantain depletes the soils of the available nutrients and after such a crop, a suitable legume such as cowpea, green gram, black gram, soya bean or ground nuts should be rotationally intercropped in the land to restore the fertility of the soil.

Fig. 23. Pineapple under coconut.

Fig. 24. Cowpea cultivation as a intercrop.

Fig. 25. Chillies as an intercrop.

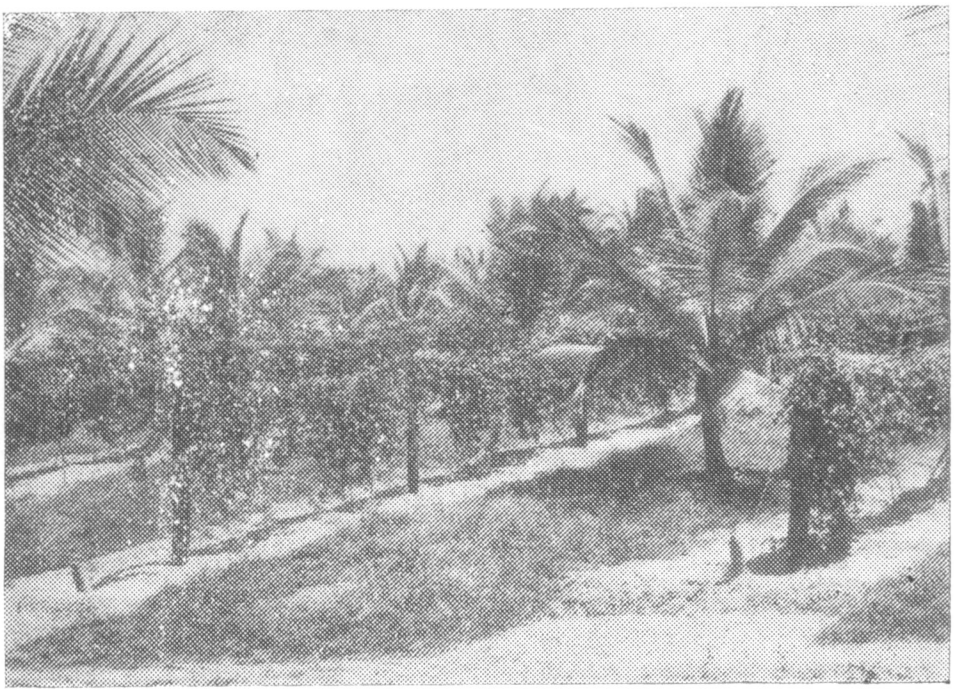


Fig. 26. Passion fruit cultivation in a coconut land.

Fig. 27. Coffee under coconut.

Fig. 28. Cocoa under coconut.

CHAPTER 13

INTERCROPPING UNDER COCONUT, PART II

PASTURE PRODUCTION AND ANIMAL HUSBANDRY

As pointed out in Chapter 12, intercropping with pasture species could be successful on the shallow, flat and shallow, undulating lands of the Wet Zone and on the deep, flat and deep undulating Low Country terrain of the Intermediate Zone of Sri Lanka (Fig. 22). Pasture production and cattle farming under coconut could play an increasingly important part in meeting the country's milk and protein needs. Animal husbandry under coconut can also increase the income received from the coconut land by a factor of several folds.

Pastures suitable for animal rearing under coconut should ideally be a compatible mixture of a good grass and a good legume. Such a mixed pasture provides grazing animals with a high quality and substantial quantity of forage. Legume foliage in addition to the grass, provides high quality protein and carbohydrates to animals and it also increases the digestibility of the herbage. Legumes are also capable of "fixing" atmospheric nitrogen and transferring it to the grass in the crop mix.

Improved pasture production by proper selection of species, suitable climatic areas and optimum management practices have been the subjects of considerable research. A good grass cover also reduces erosion and pastures digested by the animals provide excellent manure.

In pasture production under coconut, the main aim is to replace the weed cover within the space of the coconut stand with highly productive pasture species.

Pastures can be stablized under coconut spaced on the recommended square system of planting (approx. 9 m $\times$ 9 m) at about the thirtieth year after planting when light infiltrating through the canopy adequately illuminates the ground. They can also be grown while the coconut palms are yet young and do not cover the land area fully (1 - 5 years).

Pastures Suitable for Growing Under Coconut

The important species of grasses tested and found to be suitable for pasture development in Sri Lanka include *Brachiaria miliformis, B. Brizantha, B. ruziziensis, B. dictyoneura* and *Digitaria decumbens.* These grasses are mat forming types in the high rainfall areas and are therefore capable of effectively checking weed growth. *B. miliformis* also known as Cori grass representing an abbreviation for (Coconut Research Institute) and *B. brizantha* are two grasses that are most successful when grown under coconut. The former however is superior to the latter in being, cheaper and easier to establish, more tolerant to shade and being less competitive with coconut. In managing a productive pasture, it is very necessary to ensure that the grasses are adequately fertilized and if possible irrigated, to minimize competitive effects on the coconut. While the fodder grass, *Panicum maximum* appears to depress coconut yields, the pastures *B. brizantha* and *B. miliformis* show beneficial effects on coconut yield.

Under good conditions *B. miliformis* produces a large quantity of feed (Dry matter yield; 15,000 kg/ha/year) similar yields are obtained with *B. brizantha* by grazing animals — perhaps on account of its being less coarse. *B. miliformis* is preferred to *B. Brizantha.*

The legumes recommended to be incorporated in pastures under coconut are *Centrosema pubescens* (Centro), *Pueraria phaseoloides* (Puero) and *Calopogonium mucunoides* (Calope). These are normally grown in coconut estates as cover crops for soil and moisture conservation (see page 60). The perennials, *Pueraria* and *Centrosema* are more satisfactory as pasture legumes than the annual legume *Calopogonium.* They possess a greater ability to fix nitrogen and are also more persistent. There is evidence that *Centrosema* does well on heavier soils while *Pueraria* does successfully on lighter soils. It has also been observed that cattle do not accept *Pueraria* as feed as readily as they do *Centrosema.*

To get the best results, the legumes should be inoculated with nitrogen fixing bacteria specific to the crop. The soil may harbour these organisms but if the soil lacks the performance of the untreated legume will be poor. There are however problems in securing adequate nitrogen fixation by legumes under tropical conditions and also in achieving stable legume/grass mixtures.

Conversion of Pasture Constituents to Animal Products

Animals have been long recognized as a convenient means of converting grass and other leafy material into animal products such as milk, meat, leather, wool and farmyard production is the

Fig. 29. A cattle grazing on B. miliformis grown under coconut

efficiency with which the grazing animal converts the pasture into milk and/or meat. An efficient animal may be defined as one that consumes least and yields most. In the case of dairying, a convenient index of efficiency may be obtained by dividing the milk yield per lactation by the body weight. Locally available cattle types, Sinhala and Sindhi, normally have very low indices compared to the European breeds of cattle (*e.g.* Jersey, Friesian etc.). Table 15 indicates the milk-yield/body weight ratio of a number of cattle breeds found in Sri Lanka.

A "rotational cross breeding programme" based on a particular sequence of crossing the local breed and their follower hybrids, alternately with Temperate and Tropical breeds has now been in practice at the Coconut Research Institute for over two decades. It is hoped eventually to evolve a breed with good qualities and genetic stability to impart its characteristics to off-spring when bred with individuals of the same stock.

Table 15. Ratios of milk yield to body weight of some breeds of dairy cattle in Sri Lanka

Breed	*Milk yield/body weight (l/kg)*	
Sinhala	2.09	(0.25 gal/lb)
Sindhi	3.34	(0.40 ")
European (in Sri Lanka) ...	4.84	(0.58 ")
European (in England) ...	6.26	(0.75 ")
Sinhala × Friesian	5.51	(0.66 ")
Sinhala × Ayreshire	5.67	(0.68 ")
Sinhala × Jersey	5.84	(0.70 ")

European breeds of cattle do not perform satisfactorily in the Low Country because of their intoleraffice of the harsher environment. Their crossess with local breeds however are very

promising. Among them, Sinhala × Jersey cows are outstanding from the point of view of adaptability, small size, high milk yield and the richness of milk. This hybrid is suitable for the small holders as well as estate owners.

The success achieved with sheep under coconut on few estates that sheep farming is feasible and is quite profitable. Sheep farming on coconut plantations may be situated to drier areas receiving less than 160 cm of rainfall annually. Similarly, pigs and poultry can also be profitably raised.

Establishment of Pasture

The normal method of establishment is by cuttings due to the fact that most of these tropical pasture grasses do not produce viable seeds. Furthermore, there are certain distinct advantages in using vegetative materials for establishment, as this ensures a uniform stand while there is no need for land preparation to produce a fine tilth. The cuttings should be about 12 - 18 long, rooting cuttings being preferable.

The soil should be wet at the time of planting grasses, and to get the best establishment, planting should be done at the beginning of rainy periods.

The land is ploughed and harrowed and followed by the removal of shrubs and weeds. Saphos phosphate and muriate of potash at 125 kg each per ha (4 cwt per acre) are applied to the ploughed field. The grass cuttings are then spread on the prepared ground such that about three cuttings fall per metre of planting row. A harrow is now run over the area to bury cuttings. Alternatively, on smaller extents and for manual planting, holes are dug every metre and a few grass cuttings planted and covered with soil. The legume selected should be established in rows about 3 metres apart. Within each row, and at about 0.3 metre apart, 15 - 20 seeds of the legume are mixed with the soil in the top 2.5 cm and covered over.

If the soil is suitably moist and other conditions are favourable, grasses and legumes sprout in about a fortnight. A dose of sulphate of ammonia at 125 kg per ha (1 cwt/acre) should be applied at this stage to the land taking care not to drop the fertilizer directly on the legume seedlings. Farm yard manure also could be used for this purpose at the rate of about 50 kg (1 cwt) per coconut square (see CRI advisory leaflet No. 24).

Management of the Pasture Under Coconut

In about a month, the grasses and the legumes produce sufficient foliage for grazing. This should be grazed lightly as heavy grazing at this stage affects the growth and establishment of the pasture plants. The grasses get trampled on and this will help establish new rooting at the nodes of the grasses.

The pasture thus established is ready for grazing when the grass is at about 5% flowering. Grazing should be permitted to about ankle height as more severe grazing may affect the growth and persistence of the grass. Heavy overgrazing results in smoothering of the pasture by local weed species and necessitates expensive re-establishment.

A methodical rotational grazing should be practised to obtain a satisfactory grass cover. An area of a hectare of improved pasture land under coconut can normally support four dairy cattle. In rotational grazing, the land is divided into a number of paddocks depending on the number of animals and the extent of the estate. The animals are allowed to graze in the paddock at a time while the other paddocks are allowed to recover, after grazing. In the absence of paddocks, the animals should be tethered (to the trees) in the area available for grazing. (Electric fences for agricultural purposes, have proved effective though costly, in maintaining temporary boundaries for animals within the estate). The level of nitrogen application and the intensity and the frequency of defoliation affects persistence and productivity. On the basis of available evidence, a pasture should have 4 - 5 weeks between successive grazings. Grazing to a height of 3"-5" seems ideal. For fodder grasses, a cutting frequency of six weeks during the monsoons and nine weeks during the drier season with a cutting height of 6" is recommended. Considerable stress is exerted by a good pasture on available moisture and this can result in coconut yield. Therefore, during such period, supplementary irrigation should be provided wherever feasible.

The by-products of the pasture industry, the urine and dung of the animals provide the grower with a valuable manure, which may be used to supplement inorganic fertilizers. (see page 56) Systematic usage of cow dung and urine in preparing farm yard manure has been described in CRI advisory leaflet No. 24. Organic manure however offers an ideal breeding ground for the rhinoceros beetle. (Black beetle, see page 93). Therefore vigilance is required to eliminate grubs in dung heaps. Frequent disposals of the manure and clearing dung of the black beetle grubs should be adopted.

Pasture Conservation in Coconut Lands

Profitability of cattle husbandry depends on the availability of cheap food round the year and its efficient conversion into marketable products. Except in the Wet Zone, production of pasture will be seasonal so that there will be periods of excess grass followed by inadequate production of herbage. To tide over such difficulties, feed conservation could be adopted. During the Maha rainy season hay making is not likely to succeed due to heavy showers. Since ensilling is independent of weather conditions, it appears to be the most feasible alternative method of conserving. However, excess grass remaining at the end of the rainy season can be made into hay in the field and stored for use during the drought. Unfortunately not much attention has hitherto been given in Sri Lanka to silage production.

Use of Fodder Grasses

Animals can also be fed with the cut foliage of fodder grasses grown in coconut lands. Guinea grass could be successfully grown under coconuts in the Wet Zone without any loss of coconut yields provided both crops are adequately manured. Pusa Giant Napier, *Setaria* species are some other important fodder grasses.

However, stall-feeding of cattle is a labour intensive procedure and therefore pastures that can be grazed by livestock are a much preferred alternative on coconut lands in Sri Lanka.

CHAPTER 14

PESTS OF COCONUT AND THEIR CONTROL

In Sri Lanka, the coconut palm is attacked by a number of insect and vertebrate pests. In general, insect pests cause more damage. These pests attack both foliage and the trunk of coconut palms at various stages of growth, resulting in low yield or poor quality nuts. This chapter is devoted to the biology and control of these pests.

PART 1

INSECT PESTS OF COCONUT

Several insect pests which attack the coconut palm, can be broadly categorized into major pests and minor pests.

Major pests

1. Coconut leaf miner (*Promecotheca cumingi*)
2. Coconut Caterpillar (*Nephantis serinopa*)
3. Red Weevil (*Rhynchophorus ferrugineus*)
4. Black beetle (*Oryctes rhinoceros*)
5. Coconut scale (*Aspidiotus destructor*)

Minor pests

1. Termites (*Odontotermes* sp.)
2. Nettle grub (*Parasa lepida Cramer*)
3. Bag worm (*Manato albipes*)
4. Yellow spotted locust (*Aularches miliaris Linnaeus*)

1. THE COCONUT LEAF MINER, *Promecotheca Cumingi*

(Coleoptera : Hispidae)

The Coconut Leaf miner was inadvertently introduced to Sri Lanka in 1970 and caused extensive damage to coconut plantations in the first instance in the Colombo area and subsequently elsewhere.

Nature of Damage

The adult stage of the insect is a beetle and is somewhat similar in size and appearance to a firefly (S—Kalamediriya). The damage caused to the leaves is of two kinds. The larvae feed by mining the tissues of the leaflets, whereas the adults feed by making narrow grooves on the lower surface of the leaflets. Thus, in severe infestations the larvae and adults jointly make the greater part of each leaflet, and therefore of each leaf, non-functional. Since all leaves are damaged in the same way, affected palms are greatly weakened and crop is drastically reduced. The palms acquire a scorched appearance. (Fig. 31)

Life History

The life cycle of *P. cumingi* is illustrated in Fig. 30. The adult beetle which is about 7-8 mm in length is reddish brown in colour. The female lays oval shaped eggs singly on the under side of leaflets and covers them with partly digested fragments of coconut leaves and mucilage. After 13-15 days, cream-coloured brown-headed larvae emerge and burrow into the leaf causing a 'blister-like' mine. In a fully-developed mine three areas are demarcated indicating the activity of three larval instars. (Fig. 33). The larval mine may be up to 7 cm long and after about three weeks, the pupa, which is a resting stage develops in the mine. After 8-12 days in the pupal stage, the adult is formed which rests for about 2 days before emerging through the upper surface of the leaf by making a semi-circular cut. The adult can live up to about five months.

Control

Pest surveillance and prompt action are most important steps in the control of this pest. In the early stage of the infestation, the pest can be brought under control by cutting and burning the affected fronds. However, in advanced infestations such control measures are inadequate.

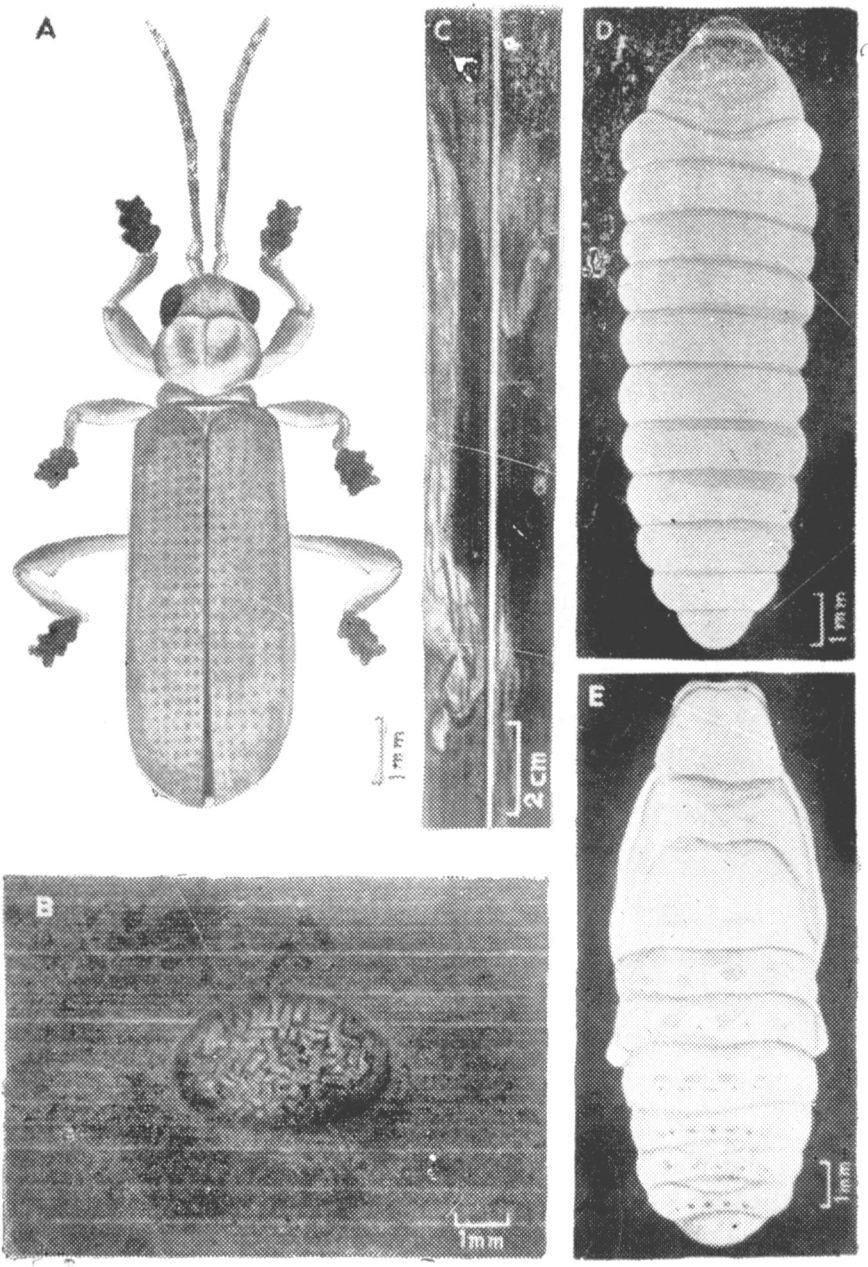


Fig. 30. The life cycle of P. cumingi A. Adult B. Eggs layed on under side of a leaflet. D. Brown-headed larvae. E. Pupa.

Fig. 31. A palm affected by Promecotheca cumingi.

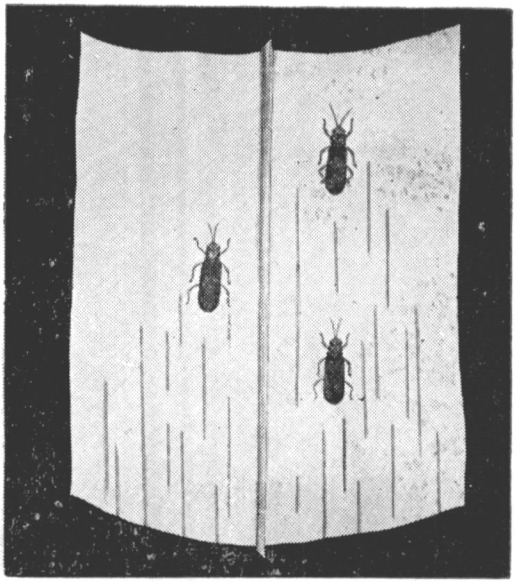


Fig. 32. Adults feeding on a coconut leaflet.

Fig. 33. Three areas demarcated in a fully developed mine.

Several insect parasites that destroy this pest have been introduced to Sri Lanka by the Coconut Research Institute. These parasites have been multiplied and released in large numbers in infested areas and very satisfactory control has been achieved. The eggs of the pests are occasionally destroyed by the egg parasite *Achrysocharis promecothecae* but the predominant parasites are the tiny wasp-like *Dimmockia javanica* and *Pediobus parvulus*, which attack the larval and early pupal stages.

This pest was effectively controlled by the above parasites. As excellent control of the pest could be achieved using parasites, no insecticides are recommended. It is however necessary that the Director of the Coconut Research Institute, Lunuwila be informed to assess the damage and to take necessary control measures.

2. THE COCONUT CATERPILLAR, *NEPHANTIS SERINOPA* (*LEPIDOPTERA; Xylorictidae*)

The coconut caterpillar was first recorded from coconut in Sri Lanka in 1905 in the Eastern Province. It is now found in other coconut growing areas of the country, often causing extensive damage.

Nature of Damage

Infested palms are easily recognised by the dried up patches on the leaflets. The caterpillars feed on the green tissue of the leaf resulting in dried brownish patches. At the same time, the caterpillars make galleries out of frass. When a large number of caterpillars are present, heavy feeding would result in a large proportion of the leaf turning brown. Under such conditions a heavily infested estate would give, to a casual observer, the impression of damage due to fire (a burnt or scorched appearance). A closer examination of the underside of a damaged leaf would show the galleries of the caterpillars as well as the different stages of the pest. The fronds, once attacked by the insect, are unsuitable for plaiting cadjans.

Life History

The life cycle of *N. serinopa* is illustrated in Fig. 34. 35 and 36. The female moth lays eggs on the lower surface of older leaflets. About 300 eggs are laid by one female. The eggs hatch into tiny blackheaded caterpillars which are pinkish in colour. They soon turn creamy white. The caterpillar stage is comprised of five instars and the fully grown caterpillars (about 15 mm long) grow into a resting stage, (pupa) from which adult moths emerge.

The male moth lives for about seven days while the female lives only for about five days. The duration of the whole life cycle is 2-2½ months.

Control

In the early stages of the infestation, further spread of the pest can be arrested by cutting and burning the infested leaves. When the pest is in the adult (moth) stage fires may be lit at dusk in the pest infested area so that the moths, which are attracted to light are killed by the fire.

Like most insect pests the coconut caterpillar too has its own quota of natural enemies in the form of birds, spiders, lizards, other insects etc. Birds such as the crow and the mynah feed on the caterpillars and pupae of the pest. In addition, several insect parasites, who are able to destroy the coconut caterpillar, have been identified and these are now multiplied in the laboratory and released in large numbers where infestations occur. These parasites lay their eggs on the larvae or pupae of the coconut caterpillar. When the parasite eggs hatch, the resulting parasite larvae feed and destroy the coconut caterpillar. In the process the parasite multiplies. These parasites are

1. *Perisierola nephantidis*
2. *Eriborus trochanteratus*
3. *Spoggosia bezziana*
4. *Trichospilus pupivora* and
5. *Bracon brevicornis*

The parasites are supplied free of charge to owners of caterpillar infested lands.

In heavy infestations, it may be necessary to use a suitable insecticide to reduce the pest population. The insecticide has to be sprayed on to the palms using motorized power sprayers and the free services of the Crop Protection Spraying Unit of the Coconut Research Institute are available for this purpose. The cost of insecticide, and other incidental expenses will however have to be borne by the land owner.

When a coconut caterpillar pest infestation is observed, it should be brought to the notiee of the Director of the Coconut Research Institute, Lunuwila.

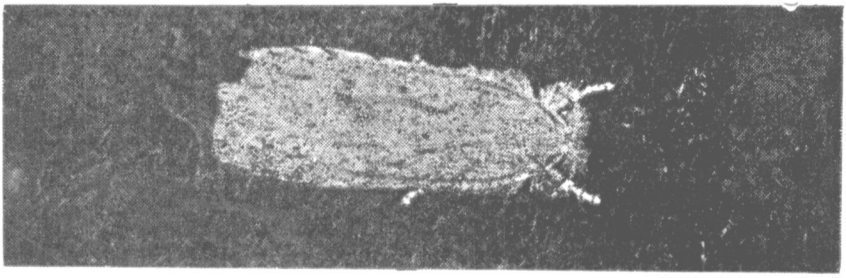


Fig. 34. N. Serinopa moth.

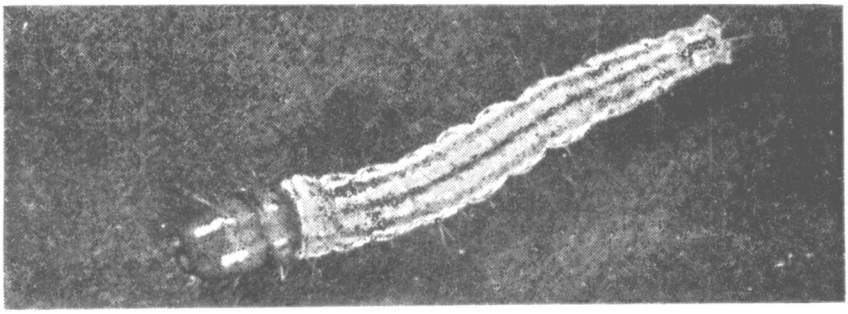


Fig. 35. N. Serinopa larve.

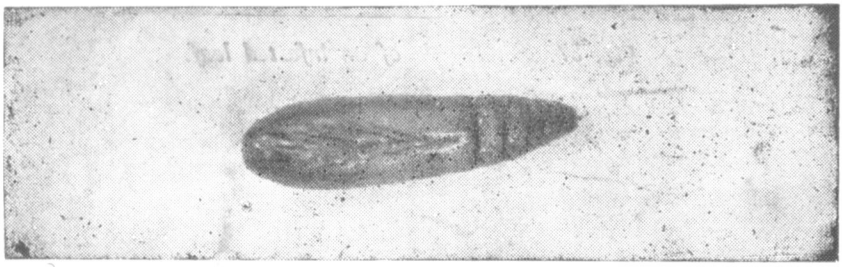


Fig. 36. N. Serinopa pupa.

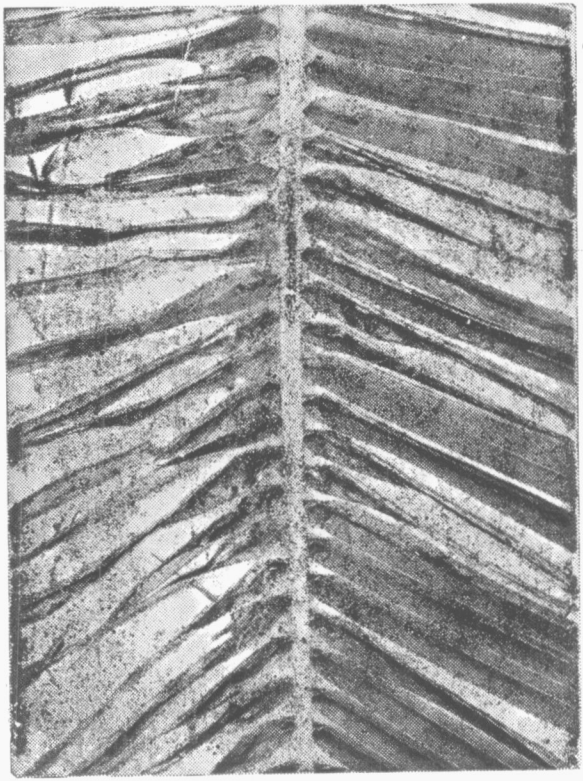


Fig. 37. Underside of an infested leaf.

3. RED WEEVIL, *RHYNCHOPHORUS FERRUGINEUS* (*Coleoptera: Curculionidae*)

This is a very serious pest of young coconut palms, often causing death. It is found in all coconut growing areas of Sri Lanka. The visual damage of this pest is not observed until the later stages of the attack and therefore early detection of the attack is very difficult. Often when the damage is noticed it is too late to rescue the palm.

Nature of Damage

The damage is done exclusively by the larvae of this pest. These larvae feed on the soft tissue inside the trunk. It is not uncommon to see gummy exudates on the trunk and frass thrown out of the trunk through small holes. Consequent to severe internal injury, the fronds may turn yellow and become withered. If the larvae reach the cabbage region, the attack can certainly be fatal. The whole palm then collapses and at this stage the palm has suffered irreparable damage. (Fig. 38) Red weevil damage often occurs with the incidence of black beetle in coconut palms (see page 92).

Life History

The life cycle of the red weevil is illustrated in Fig. 39, 40, 41. The adult which is about 4 cm long and 1 cm broad is reddish brown in colour with a long curved snout.

The female weevil lays eggs in wounds on the coconut palm caused by man, grazing animals, other insects such as the black beetle and by other methods. The female is attracted to fresh injuries on the trunk or on the petioles. The adult female lives for 3-4 months, during which period 200-500 eggs are laid. The incubation period of the egg is 3 days. The larvae which emerge, burrow into the trunk direct or through petioles and start feeding on the internal soft tissue in the trunk. A fully grown larvae has a brown head and a white body and is about 6 cm in length (Fig. 40). The larval phase lasts for 2-4 months after which they become pupae under the bark in a cylindrical cocoon (Fig. 41) made with fibre of the stem tissue. The pupal cocoon is about 8 cm long. The pupal stage lasts for about 14 days after which the adult emerges through a hole made on the trunk.

Control

As the detection of red weevil damage is very difficult, and the damage when advanced is irreparable, extreme care should be taken by growers, particularly in young plantations, to prevent access to the pest.

Preventive Measures

Emphasis should be placed on preventive measures as far as possible. The following guide lines may be of use :

(1) Survey young palms to detect the early stages of attack. Trained personnel can detect the feeding noise of the larvae, particularly at dusk, inside the trunk.

(2) Apply coal tar on all fresh wounds on trunk and petiole and also on cut ends. Tar coating repels adult females from laying eggs. Sometimes one application of tar may not be sufficient and it should be applied periodically on the wound. It is also advisable to clean and dress the wounds caused by the stem bleeding disease (see page 106) as otherwise female weevils could lay eggs on such wounds. The damage by the black beetle is also a convenient entry point for the Red Weevil. The control of black beetle is therefore an integral part of the management of the Red Weevil pest.

(3) Palms which have succumbed should be cut, split and burnt to destroy the pest inside the trunk as otherwise such palms will be a source of infection. If the infestation has been detected in time, an application of a systemic insecticide, as described below, is essential.

(4) Use of red weevil traps could reduce the pest populations. A bait (fresh split coconut petiole) is used in the cage which attracts the adult weevils. Traps must be examined every two or three days and the trapped weevils should be destroyed. The bait should be changed every 10 days. Fig. 42 shows the construction plan of the red weevil trap.

The trap is essentially made of two parts, the top trapping part and the metal tray. The two parts may be joined together with hinges if desired.

Chemical Control

If the damage is detected early, the palm may be rescued if treated with suitable systemic insecticide. As the pest is lodged securely inside the trunk, it is necessary to administer the insecticide into the trunk. This is normally done using a funnel as described below.

1. Make a hole about 5 cm deep, 10-15 cm above the suspected point of attack on the trunk of the palm by driving an auger or a narrow chisel in a downward oblique direction (Fig. 44). The width of the hole should be as small as possible.

Fig. 38. A coconut palm affected by Red Weevil.

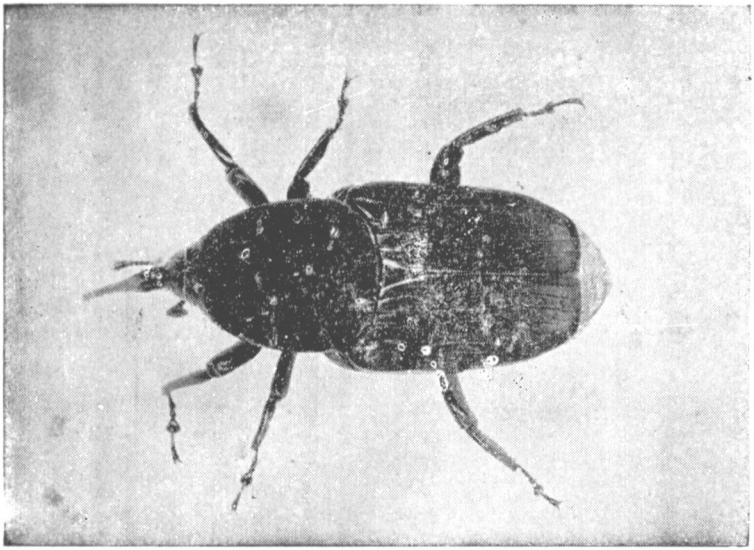


Fig. 39. Adult Red Weevil.

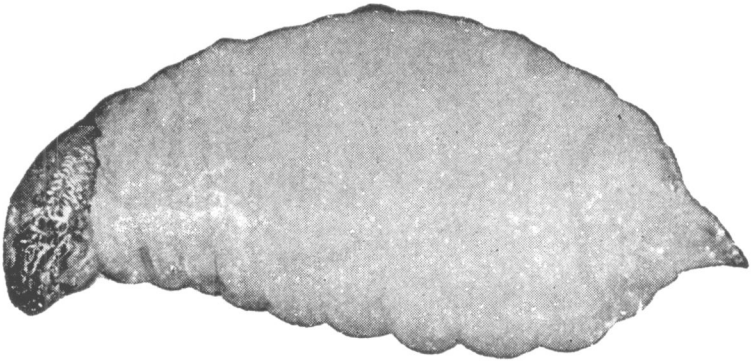


Fig. 40. Grub of Red Weevil.

Fig. 41. Pupa of Red Weevil in cocoon.

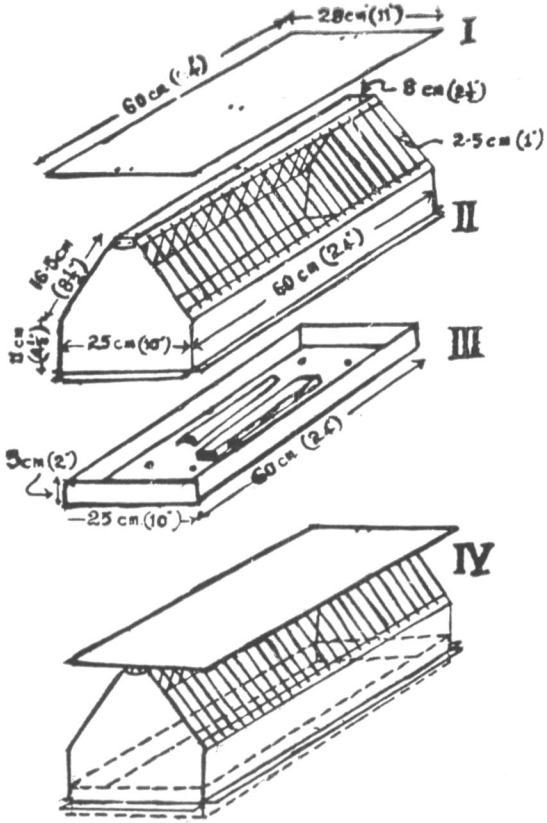


Fig. 42. The construction plan of the Red Weevil trap.

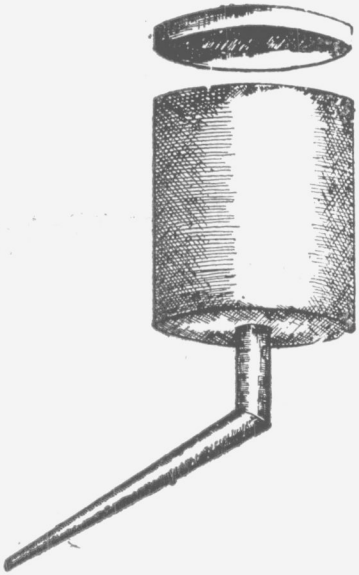


Fig. 43. Tin funnel.

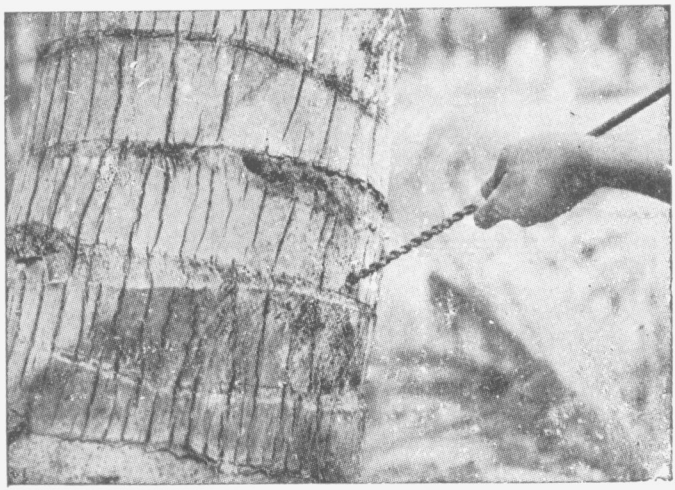


Fig. 44. Drilling hole for inserting funnel.

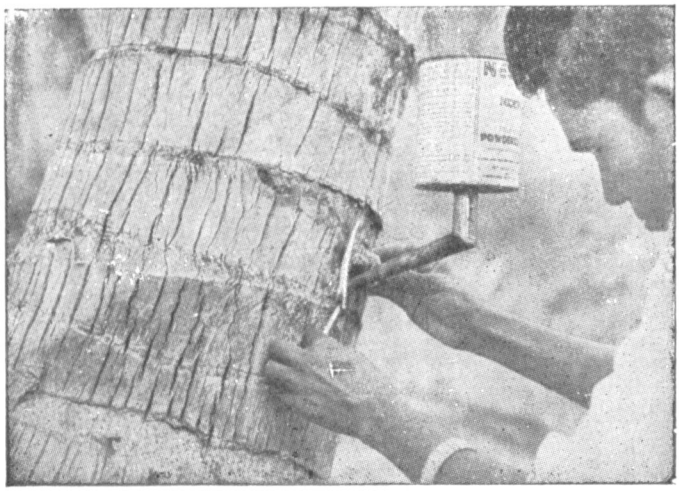


Fig. 45. Fixing funnel with sealing materials.

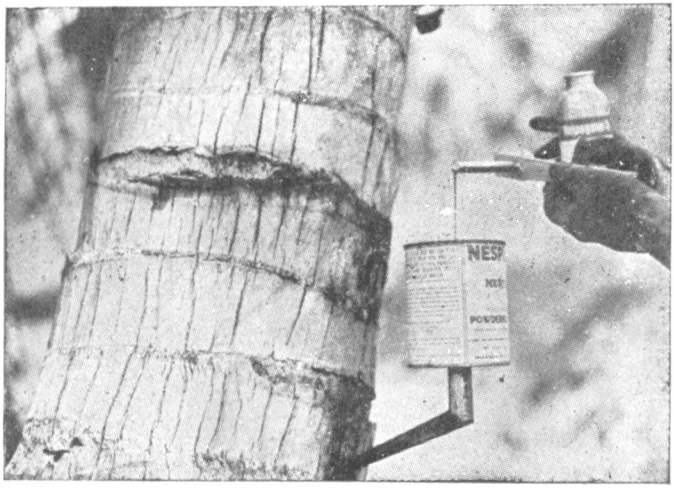


Fig. 46. Introduction of insecticide,

2. Insert the oblique funnel stem into the hole, keeping the funnel erect.

3. Warm some sealing material (prepared by heating old jak fruit latex (koholla) and some gum resin) and apply it around the funnel stem at the mouth of the hole on the trunk. The sealing compound should be properly plastered. The funnel may be tied to the trunk for extra support.

4. After about five minutes, pour about ½ cup of water into the funnel. If there are leaks from the hole, the funnel should be removed, cleaned and fixed again. If there are no leaks, add another 1½ cups of water.

5. Measure out 4 teaspoonfuls of the insecticide (see appendix for the recommended insecticides) and pour into the funnel.

6. Close the lid of the tin funnel.

7. Wash hands thoroughly with soap and water.

8. Fix a warning board or a tag on or near the palm.

Important :— Insecticides are extremely poisonous and should be handled with extreme care. Avoid spilling. Use gloves when handling. Stir the solution in the funnel with an ekel and bury the ekel. Now close the insecticide container tightly with the lid. Please refer to the list of precautions and antidotes in insecticide poisoning given in Appendix.

The insecticide solution is slowly absorbed into the trunk and destroys larvae feeding on the tissue. A satisfactory kill of the pest can be achieved within about four days. If the infestation is heavy on the palm a second insecticide application is advisable. If the attack is mild the funnel could be removed in four days and the hole plugged with cement and sand mortar (1:3). If there are other cavities these should be cleaned, dressed with coal tar and filled with the mortar. Young palms which have been heavily damaged by the red weevil should be supported with props for sometime until recovery. In a heavily infested estate it is advisable to treat healthy young palms standing close to the infested palms.

4. THE BLACK BEETLE, *ORYCTES RHINOCEROS* (*Coleoptera: Dynastidae*)

The black beetle, also known as the rhinoceros beetle is widespread in Sri Lanka. Although not a serious pest, occasional outbreaks do occur. Adult palms can withstand the attack without adverse effects but when seedlings and young palms are attacked, the growth is very much retarded and mortality is not uncommon.

Nature of Damage

The damage is done exclusively by the adult beetle. It enters the cabbage region and chews on the tender shoots which are rich in sugars.

In the process, frass is thrown out. When heavily attacked, developing inflorescences too could be damaged. When the attacked leaves expand, the damage is visible as a characteristic geometric cut on the frond. (Fig. 47)

Life History

The adult beetle which is shiny brownish black in colour and is about 4 cm in length and 2.5 cm in breadth bears a characteristic horn on the head (hence the name rhinoceros beetle). Adult beetles are active at night and are attracted to light. (Fig. 48)

The life cycle of the black beetle is illustrated in Fig. 49. The eggs are laid in moist, decomposing vegetable matter and wood matter. Cow-dung heaps are the commonest breeding ground of the black beetle in Sri Lanka. The egg is whitish brown and is 3-4 mm long. The eggs hatch in 7-18 days and the emerging larvae feed on the decaying vegetable matter. When fully grown the larva measures 60-105 mm in length. The larva has a whitish body with a brown head, and is mostly seen curled. The larval phase lasts about 130 days. Pupation takes place in soil or in rotten vegetable material or in decaying coconut trunks. When a breeding place is examined, pupal cocoons which are about four cm long, can be seen. The pupal phase lasts about 20 days. The adults emerge and rest for about 10 days. The total life cycle is about 6 months. The beetles live mostly near the breeding sites, spending a relatively short time on coconut palms. The adult lives for about 3 months. Each female is capable of laying about 150 eggs.

Fig. 47. A young palm affected by Black Beetle.

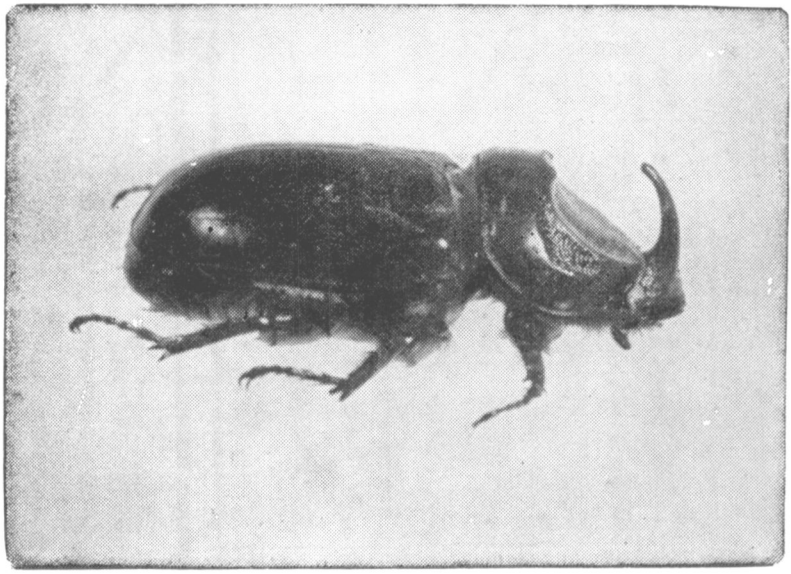


Fig. 48. Adult Black Beetle.

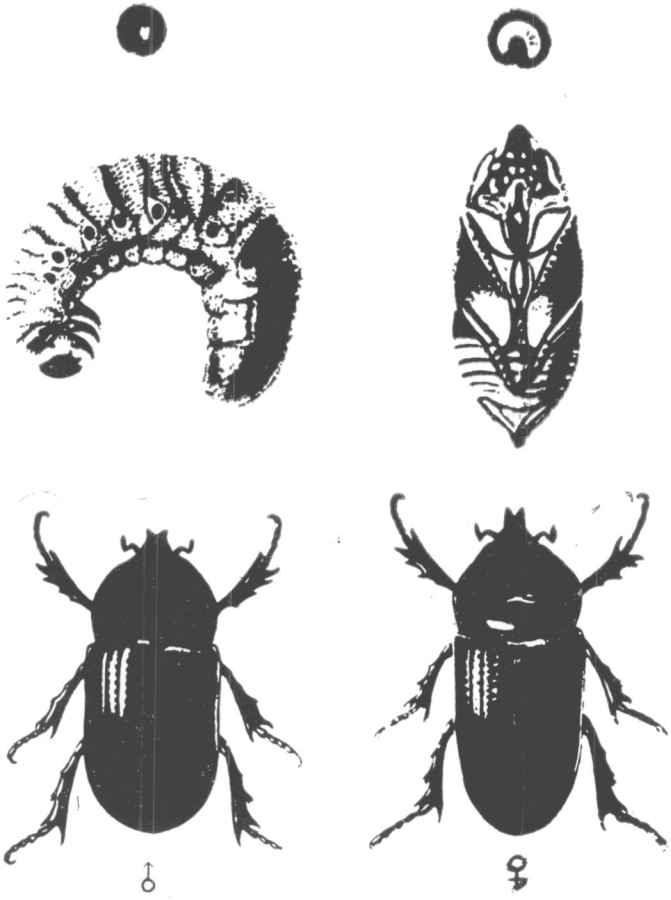


Fig. 49. Different stages of the life cycle of **Black Beetle.**

Control

This pest could be easily controlled by cultural practices and by good estate sanitation. As the young stages of the beetle live in decaying organic matter, elimination of such breeding places would be highly desirable to control the pest effectively. Where possible, all manure heaps should be utilized early without leaving them to attract more black beetles. If large numbers of larvae are found in manure heaps, mixing an insecticide like BHC would be advisable. In coconut estates, fallen coconut trunks and boles should be split and burnt.

In Sri Lanka, natural death of this pest due to a virus (*Baculovirus*) and due to a fungus (*Motarhizium anisopliae*) is occasionally encountered.

Young coconut plantations should be regularly examined for black beetle damage by trained personnel. If activity is noticed beetles could be easily extracted with a metal hook. As a prophylactic measure, insecticides (see appendix) could be used in the crown area as repellants.

5. COCONUT SCALE, *ASPIDIOTUS DESTRUCTOR*

Homoptera: Coccidae

The coconut scale can be a serious pest on coconut palms. Under dry conditions the pest could appear in large extents of coconut plantations. The pest commonly occurs in the North-Western, Western, Southern and rarely in the North Central Provinces of Sri Lanka. In addition to coconut the pest is found in other palms, and in small numbers only, on a variety of other cultivated plants including tea, rubber, mango, papaya, etc.

Nature of Damage

In mild infestations the pest damage could be seen as small patches on leaflets. In a single palm, a few leaflets of several mature lower fronds may be initially infested and the insect may gradually spread to adjacent leaflets. When heavily infested the entire frond may turn yellow.

To deal with a scale infestation, it is most advisable to cut down a few affected leaves and examine the lower surface. If the pest is present, a white incrustation of scaly matter will be seen. The scale insects are easily recognizable with a hand lens.

If the pest is present, a simple test to ascertain whether the infestation is fresh is to collect a few scales by running the thumb over the scaly matter. If the scales are dead, the collected scales will be blown-off and if alive, the collected scales, when pressed, will be moist.

Life History

The life cycle of this pest is illustrated in Fig. 50. Young scale insects ("crawlers") emerge from eggs. They could be seen easily with a hand lens crawling on the leaflet in search of fresh locations for settling and feeding. Within two days, the insect becomes sedentary, sucking the leaf sap from the underside, whence it forms a scaly covering. The sedentary female scales are bright yellow and nearly circular in shape resembling a fried 'bulls-eye' egg. The males which are capable of flying, are extremely small and are not visible to the naked eye. An average of about 60 eggs are laid by a female. The eggs are packed around the mother scale under the covering. Eggs soon hatch into 'crawlers' and the life cycle starts again.

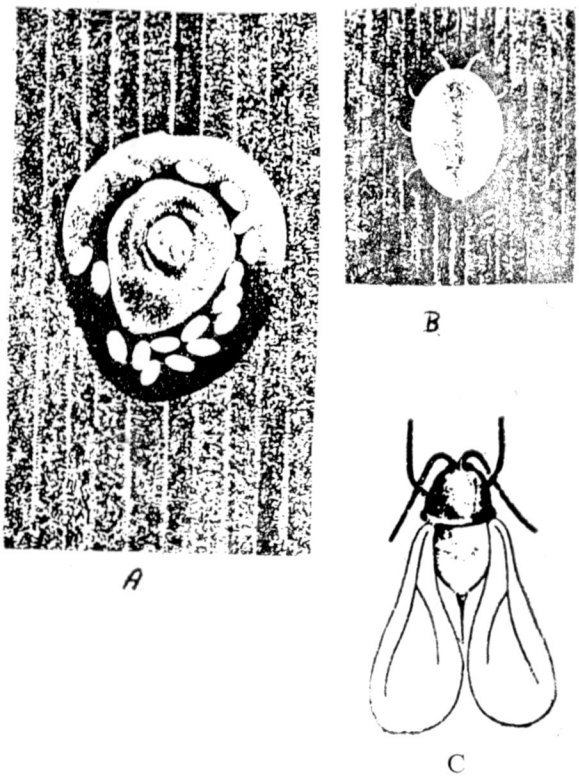
Control

In areas where the pest is known to occur, it is necessary to be vigilant and detect the pest early. In some areas the insect is known to occur throughout the year in small patches without causing serious damage to the palms. At this level of pest incidence, control measures are unnecessary and uneconomic. During the early part of an outbreak, satisfactory control could be achieved by cutting and burning the infested fronds.

Control by Natural Enemies

In nature there are parasites and predators which can keep the pest under check or sometimes even effect control in an outbreak.

The parasite *Aphytes chrysomphali* is a tiny flying insect and is found commonly in infestations. A black mold too is sometimes found attacking scales under humid conditions. The adults and larvae of the lady bird beetles, *Chilocorus nigritus* and *Pullus xerampelinus* are the common naturally-occurring predators of the scale insect. The adult *Chilocorus* is black and roundish while those of *Pullus* are brown and oval. The larval or immature stages of these insects eat coconut scales. The larvae of both these kinds is about the size of a rice grain, but *Pullus* which is cottony in appearance can be differentiated from *Chilocorus*, which is dark brown with a few hairy projections.



A. — Adult female scale with eggs

B. — Young larva or crawler of coconut scale

C. — Adult winged male of coconut scale

Fig. 50. The life cycle of Coconut Scale.

Chemical Control

If the infestation is advanced and the natural enemy population is insufficient, a rapid control could be obtained by spraying infested fronds with kerosene oil/soap emulsion prepared as follows :

Warm 4½ l (1 gal) of water over a fire. Add 225 g of laundry soap shavings, stir and dissolve. Once the soap is completely dissolved, remove the solution from the fire and add 9 l (2 gal) of kerosene oil in small quantities, stirring the mixture continuously. A heavy emulsion will then be formed. This is the stock solution, which should be diluted ten fold before spraying.

Ingredients to spray about 20 grown-up palms

For the stock solution

—	Kerosene oil	18 l
—	Water	9 l
—	Laundry soap	450 g

To make the spray fluid add 270 l of water to the stock solution.

Special care should be taken to stir the spray fluid while spraying. Otherwise kerosene oil will tend to separate, spraying of which will be harmful to the palms. The services of the Crop Protection Service Unit of the Coconut Research Institute, which is equipped with motorized power sprayers, can be had free of charge but the estate has to supply the ingredients for the preparation of spray fluid and a few labourers. Please contact the Director, Coconut Research Institute, Lunuwila in the event of an outbreak.

TERMITE, *ODONTOYERMES* SPECIES

(*Isopteta, Termitidae*)

Termites are commonly known as "white ants". There are several species of termites damaging coconut seedlings. They occur in all coconut growing areas in Sri Lanka, and are more abundant in clayey soils.

Nature of Damage

Termites usually damage seedlings in nurseries and after transplantation. The husk and the stem are attacked resulting in withering of the seedling. When the stem is attacked the young seedling is often damaged beyond recovery. Sometimes, termites enter and devour seednut contents. Such an entry is easily recognizable because of the presence of sand grains at the point of entry.

Control

Termite mounds in plantations should be levelled to the ground to eliminate the pest. At transplanting it is advisable to take prophylactic measures against this pest. There are several insecticides in the market which could be used for this purpose. These are given in the Appendix.

NETTLE GRUB, *PARASA LEPIDA* (*Lepidoptera, Limacodidae*)

Infestations of nettle grub though comparatively rare, can be highly destructive. The leaflet blades are eaten up by these caterpillars and in severe infestations only ekels are left intact, (see Fig. 51). The droppings of caterpillars can be seen on the ground.

Life History

The adult *P. lepida* is a moth with light brown wings which are light green at the distal ends.

The eggs are laid by the female moth in clusters on the underside of leaflets. After about seven days the tiny caterpillars hatch out. As the caterpillars consume coconut leaf and grow up, distinct olive coloured stripes appear on the body (Fig. 51). The fully grown caterpillar is about 3.5 cm in length and is light green in colour. Numerous spines are present on the body which are a venomous sting (thus 'stinging caterpillar'). After about 50-60 days they turn into pupae in hemispherical cocoons. The moths emerge from the cocoon in about 50 days.

Control

If the pest is detected early when they are few in number the infested fronds should be cut and burnt. In the field, a number of naturally-occurring parasites keep the pest under check. If the infestation is extensive, judicious spot spraying of an insecticide such as Gamma B.H.C. may be carried out. If an infestation is detected, the Director of the Coconut Research Institute should be informed immediately for advice.

BAG WORM, MANATA ALBIPES (Lepidoptera, Psychidae)

As the name implies, this is a caterpillar pest living in a 'bag' attached to coconut leaflets. The characteristic symptom is punctured leaflets due to pest damage. After the caterpillar period is over, they pupate in 'bags' and eventually a moth emerges.

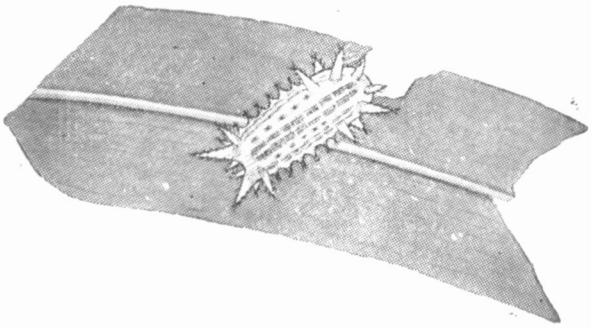


Fig. 51. Nettle grab caterpillar feeding on a leaflet.

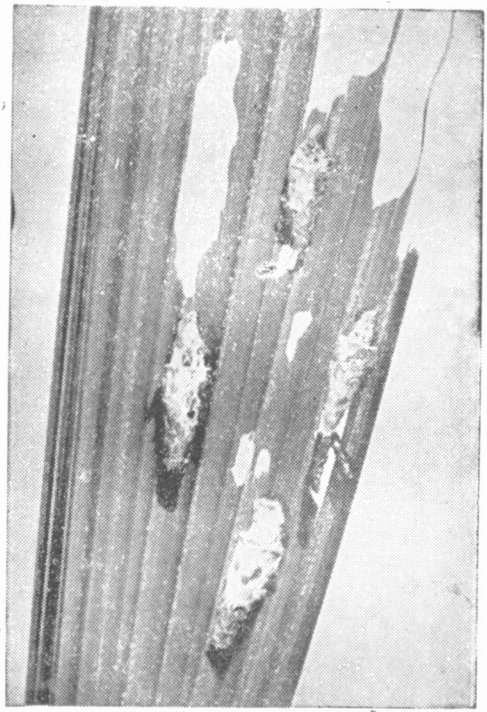


Fig. 52. Bag Worm feeding on a leaf.

Fig. 53. Bag Worm damage on a seedling.

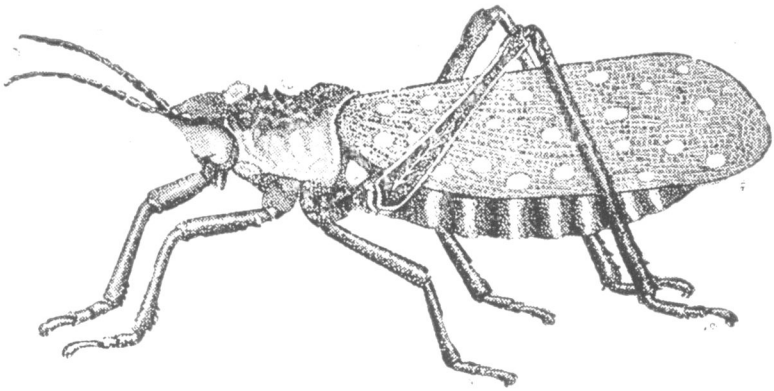


Fig. 54. A yellow spotted locust.

Control

Mild infestations are often not harmful to palms and do not warrant any control measures. However, heavy attacks, particularly on seedlings should be controlled by spraying an insecticide like Gamma B.H.C.

YELLOW-SPOTTED LOCUST, *AULARCHES MILIARIS*

(Orthoptera, Acrididae)

The locust is a polyphagous insect and can be a troublesome pest on plantations close to jungle areas. When large numbers of adult locusts are present, they can cause extensive defoliation.

The eggs are laid in the soil in pods each containing about 75 eggs. They remain dormant for a long period before hatching out with the onset of rains. The 'hoppers' that emerge are initially pinkish in colour, soon turning brownish. They occur in large aggregations feeding on the vegetation they come across. After several months, the 'hoppers' develop wings and fly out to higher canopies. Fully grown adults mate and move down to the ground for egg laying.

Control

It is very difficult to control adult locusts as they are found everywhere. It is much easier to control the young 'hopper' stage by dusting with an insecticide like Gamma B.H.C.

PART II

VERTEBRATE PESTS OF COCONUT

An occasional minor problem in coconut plantations is the presence of vertebrate pests. In Sri Lanka, vertebrate pests of coconut are bats, rats, bandicoots and porcupines. Rarely. monkeys damage young nuts but more often cattle damage to coconut seedlings is evident.

Bats

Bats sometimes feed on tender coconuts. They roost on large trees and visit coconut palms for feeding. Bats also chew up the ends of coconut fronds, damaging the leaf. In certain localities, coconut palms are regularly visited by bats.

As a control measure shooting and lighting crackers to scare the bats away can be recommended.

Rats

Rats damage young coconuts and seedlings. In bearing palms rats bore into tender nuts and eat the contents.

Unopened inflorescences are also sometimes damaged by rats. The form **Nawasi** is more susceptible to rat damage than other coconut forms.

Seedlings are often attacked by rats to gain entry into the seednut to eat the 'apple'. In the process, irreparable damage is caused to the stem, often resulting in death of the seedling.

Several methods can be recommended to prevent rat damage.

Palm Banding

Banding of coconut palm trunks using a smooth surfaced metal band of aluminium of galvanised iron, about 15 cm broad can be recommended. This would prevent rats from climbing the tree to reach nuts. The metal bar should be nailed to the trunk. In a heavy infestation, it would be worthwhile to band all the palms. The banding procedure is illustrated in Fig. 55

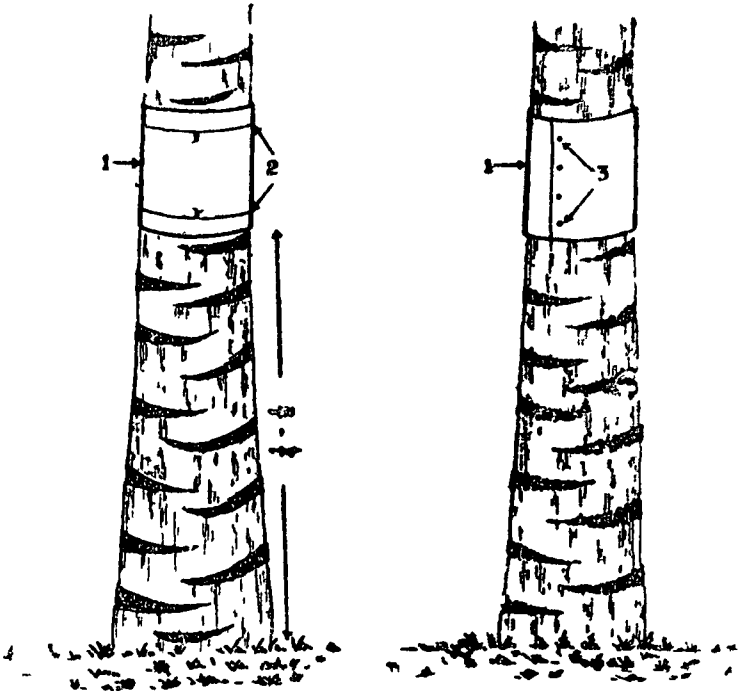


Fig 55 Illustration of banding process

The leaves of banded palms should not come in contact with those of other palms as rats can then move from palm to palm along the leaves. It is necessary to "isolate" banded palms by cutting the tips of leaves that touch those of other palms. Prior to banding, crowns of palms should be cleared of rats and their nests.

It should be noted that this method only prevents rats from damaging nuts. It does not kill rats and they will move on to unprotected coconut palms or find other food.

Estate sanitation and destruction of breeding grounds

Rats prefer to live under heavy weed cover, in husk and rubbish heaps, among fallen fronds, rotting stumps etc. It is therefore necessary to regularly control weeds in coconut plantations and to maintain a high degree of estate sanitation, to prevent colonization by rats.

Chemical Control

Several very effective and cheap rodenticides are available on the market. The rodenticide should be mixed with a bait such as fresh cereals, manioc, groundnut, copra, partly burnt coconut kernel etc. One part of poison (rodenticide) may be mixed with about 20 parts of bait. Bait may be left on the ground about every fifty feet in the infested area.

It is necessary to place the bait without poison in the field at first. In this manner, 'pre-baiting' should be carried out for about two or three days to determine whether the bait is acceptable to rats. If the bait is not acceptable an alternative bait should be used.

If the bait is left in the open, it will become mouldy during wet weather and will not attract rats. It is therefore necessary to place the bait in a container and provide a shelter over it (see Fig. 56). Mouldy baits should be renewed. The bait may also be placed on the trunks of palms as shown in Fig. 57.

It should be noted that rats fed on rat poison go in search of water. It is therefore advisable to cover water tanks, wells, etc. to prevent poisoned rats from getting in. Baiting should

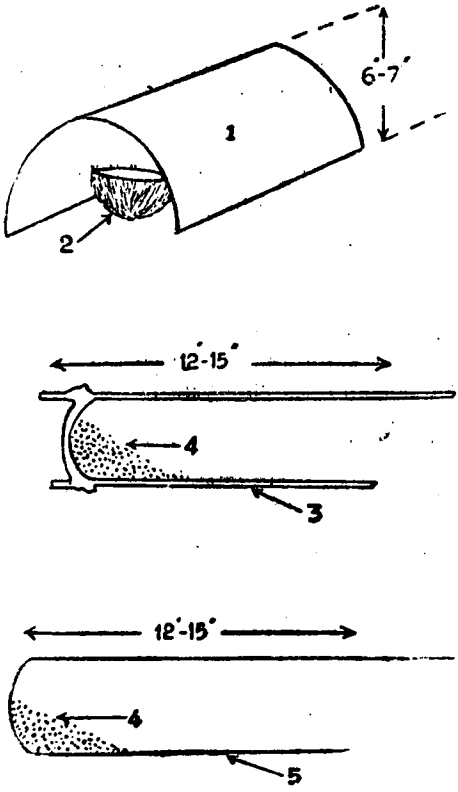


Fig. 56. Baiting on the ground.

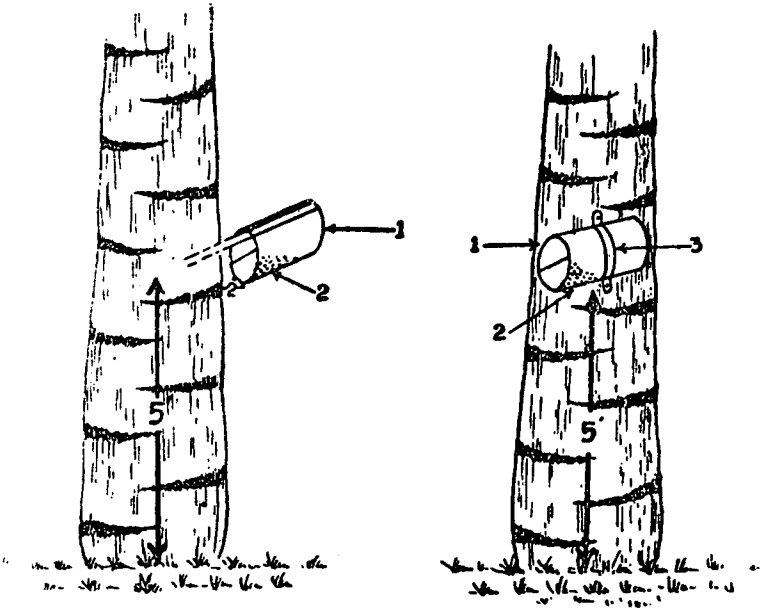


Fig. 57. Baiting on the trunk.

not be done continuously in the same area The field should be free of bait for short periods as rats tend to avoid bait-containing poisons, kept on for long periods

Rat traps may be used to control small populations of rats in places where it is dangerous to use rat poisons

Porcupines

In young plantations near jungles, porcupines can be pests on seedlings and young palms They attack the plant by feeding on the tender portions of the 'stem'

Porcupine damage may be reduced by protecting seedlings with fences of wire mesh around the base Good estate management practices will reduce porcupine populations When infestations occur, it is advisable to regularly paint the bases with a strong-smelling coal tar preparation

CHAPTER 15

DISEASES OF COCONUT AND THEIR CONTROL

In Sri Lanka, coconut suffers from a few diseases, which are of minor importance In addition to the known fungal diseases, disease symptoms due to physiological causes are seen on neglected palms due to water - logging and due to adverse soil conditions Furthermore, nutrient deficiency also brings about symptoms

FUNGAL DISEASES

Three fungal diseases are discussed below

Bud Rot Disease

Bud rot disease in coconut is caused by a fungus *Phytophthora palmivora* This disease is not widespread, but is seen in humid areas It is also found to attack young palms in under-plantations

Under humid conditions, the fungus enters the cabbage causing a decay to the growing point of the palm resulting in death After the bud has been affected the palm cannot be rescued

Initial symptoms include wilting and drying of the bud which would eventually collapse The affected bud gives a very bad odour (Fig 58)

Control

Affected palms cannot be rescued In order to arrest the spread of the pathogen, affected palms should be cut and burnt As a prophylactic measure crowns of unaffected palms should be treated with a copper fungicide A method of treatment is given below

1 Cut out pieces of jute hessian or gunny 20 cm square Place a handful of coir dust on the piece of jute hessian and tie up to make a small bag Leave the two ends of the twine long enough to tie the bag to a leaf petiole

2 Keep bags immersed in 1% copper fungicide solution overnight After air drying, the bags may be placed in the axils of the palm The bags may be recharged with fungicide and replaced at the axil every two months

Rain water releases the fungicide from bags and deposits on the bud region preventing the establishment of the pathogen.

If it is desired to keep an affected palm for the immature nuts to develop, the bud region should be regularly treated with a copper fungicide solution until the palm is cut and burnt.

Bordeaux mixture

Dissolve 459 g of copper sulphate in water, separately, mix 450 g of quicklime in 22.5 l of water. Then mix together pouring the copper sulphate solution into the lime-mixture. A vigorous stirring is necessary to make a proper mixture.

Bordeaux paste is prepared as follows:

Dissolve 450 g of copper sulphate in 2.25 l of water, Separately 450 g quicklime in 2.25 l water. Then mix the copper sulphate solution and the lime mixture. The mixing should be done thoroughly.

Leaf Blight Disease

The leaf blight disease is prevalent mostly in neglected young plantations where it can cause retardation of growth.

The disease appears as brown spots on leaflets which coalesce to form larger lesions. Sometimes, extensive areas are blighted giving a scorched appearance to the seedlings. The blighted areas may be blown away leaving only the ekel.

Several fungi, notably *Pestalozzia palmarum* and *Dreckslera incurvata,* are found associated with the lesions. However, it is unlikely that these fungi are the primary cause of leaf blight. It would appear that the leaf tissue is weakened by physiological factors thereby allowing saprophytic and weakly parasitic fungi to establish.

Occurrence

The disease can be troublesome when it appears on seedlings. Occasional outbreaks on young palms occur during dry weather when young palms suffer loss of foliage resulting in a setback to growth.

The disease is observed in ill-managed plantations where there is a nutrient imbalance in the soil. Further, waterlogged conditions too favour the disease where it can remain endemic.

Fig. 58. A palm affected by **Phytopthera palmivora**.

Control

The plants can be prevented from infection by supplying a properly balanced fertilizer. It has been observed that palms deficient in Potash are vulnerable to infection. Additional doses of Potash should be applied to affected palms.

Occasionally, if the blight is very extensive and the improvement to the palms after fertilizer application is slow, a fungicidal treatment with 1-2% copper fungicide may be considered. The necessity for a fungicidal spray is unlikely.

Stem Bleeding Disease

Stem bleeding is a minor disease of coconut caused by the fungus *Ceratocystis paradoxa*. The fungus could enter directly through wounds on the trunk. When the bark of the trunk is damaged due to excessive nutrients in soil, fluctuation of water table in soil, to fire or lightning or due to insect attacks, the fungus could enter the trunk through such openings causing stem bleeding.

Symptoms

The disease could be recognized by the rust coloured liquid which oozes out of the longitudinal patches on the trunk. (See Fig. 59). One or more such patches may coalesce forming a large brown patch. The older patches dry up leaving the brown liquid stains which turns black after some time. An examination of tissue under the bark of such brown patches would reveal an extensive rot.

Control

The affected portion on the trunk should be removed using either a chisel or hand adze until the healthy tissue is exposed.

The wound should be dressed with an application of coal tar.

PRE-DISPOSING FACTORS PROMOTING DISEASE IN COCONUT

There are several pre-disposing factors which promote the incidence of diseases in coconut. It is commonly known that high humidity is conducive to bud rot and leaf blight diseases. Collar rot of seedlings, due to improper planting, is occasionally seen. If the seedlings are planted too deep, the collar region of the seedlings gets covered with soil resulting in collar rot brought about by fungi. This can be prevented by transplanting with the collar region exposed to the air. Similarly, lighting up fires has to be done at safe distances from the palms. Otherwise the trunks are damaged pre-disposing them to stem bleeding.

PHYSIOLOGICAL DISEASES

1. Leaf Scorch Decline of Coconut

Leaf Scorch Decline of coconut is prevalent mostly in the Southern Province of Sri Lanka. The most characteristic symptom of this decline is necrosis or scorching of free ends of leaflets. As the decline progresses, the scorching advances along the leaflets. In the initial stages of the decline, only a few lower fronds may be affected, but in the advanced stage about 2/3 of the crown is affected. The leaflet ends curve inwards.

Other symptoms are —

(*a*) Thinning of the crown

(*b*) Tapering of the trunk

(*c*) Narrower nuts and

(*d*) Extensive root decay

The full course of the disease may take 2 - 6 years after which the palms die.

The symptoms of Leaf Scorch Decline should not be confused with those due to magnesium deficiency, leaf blight and tapering due to neglect.

Although investigations have been carried out on this disease for a long period of time, no condusive evidence is available to implicate a pathogen. The disease is mostly found on lateritic soils with a hard pan. It is also observed when the water table is high. Soil amelioration has been found to give beneficial results by inducing new root formation.

At a distance of about 1 m from the base of the affected palm, a circular husk bund is made to a height of about 50 cm and the cavity is filled with nutrient rich soil. This would induce new root formation.

2. Nutrient Deficiencies

Sometimes symptoms of nutrient deficiencies may resemble those caused by diseases.

For a description of the main symptoms caused by deficiencies of important nutrient elements, please refer to the appropriate section.

Fig. 58. A palm affected by **Phytopthera palmivora**.

CHAPTER 16

CARE AND MAINTENANCE OF A COCONUT PLANTATION

Just as much as a young plantation, the bearing plantation needs care and attention. The damage from pests and diseases can then be minimised.

Past chapters (Chapters 9, 10, 11) dealt with the essential management operations in a coconut plantation. Routine weeding, regular applcation of fertilizer, establishment of cover crops, and soil and water conservation measures are the basic requirements for a productive plantation of coconut. Besides these factors, regular observation and maintenance are important in many ways.

In taking care and maintaining an estate three basic aspects should be given attention, *viz.* Regular Surveys, Estate sanitation and refraining from Lighting fires.

Regular surveys

Trained personnel should be engaged in surveying the palms as regularly as possible (at least once a month). Such a surveyor would inspect each palm thoroughly for disease and deficiency, symptoms and pest attack.

Black beetle damage is visible on the opened fronds as characteristic cuts (page 93). If such signs are seen, special care has to be taken to prevent further damage. It has been mentioned that black beetle can abort an inflorescence completely, if it is attacked once. Thus, an insecticide such as gamma B.H.C. (10% powder) should be sprinkled near the bud region as a repellant. Breeding places of the black beetle should also be surveyed (see below). The unopened bud of the palm should be carefully examined to see if any entry and feeding holes are present on it (see page 94). If beetles are found feeding in the bud then they should be carefully removed with a metal hook and the wounds treated with tar. If the bud region is found withered and sometimes collapsed it is apparent that the palm has been attacked by the bud rot disease (page 104) or by a lightning strike. Such palms should be treated accordingly.

In regular surveys, the observer should look for any signs of leaf yellowing. It is important to observe carefully the nature and the positioning of the yellowing. It has been mentioned

elsewhere that the yellowing of leaves may be the result of several factors (*eg.* coconut scale attack — page 94) magnesium deficiency (page 55) water logging (page 67) or general neglect. The responsible factor should be identified carefully and treated promptly. If advice is needed the Coconut Research Institute should be consulted immediately.

Any signs of damage to leaflets, *e.g.* browning, shrivelling, scorching, may mean that the leaflets are attacked by one or more of the following, coconut caterpillar (page 88), coconut leaf miner (page 87) leaf blight disease (page 105), leaf scorch decline (page 107) and magnesium deficiency (page 55). A trained observer can easily identify the cause of the observed symptoms. Any signs of leaf eating may indicate the presence of caterpillar, nettle grub, (page 97) or attack by the yellow spotted locust (page 98). Normally locusts do not harm tall coconut trees until they reach medium size and the winged stage. Closer examination of the frond will help to identify the actual causal agent.

Any unusual appearance on the stem of the palms should be carefully noted. Any unusual holes appearing on the stem could well indicate that red weevils are present inside the stem (see page 90). When adult red weevils emerge, they bore through the stem making the hole. However, a trained person can easily identify the damage by examining the hole. If the indications are positive, then immediate action should be taken to contain the pest. It should be noted that the red weevil on coconut is extremely dangerous as, if not detected early and treated, it will result in complete collapse of the palm. It may be correct to say that palms fall victims to red weevil mostly through the negligence of the grower. Any wound caused unwittingly on the trunk or at the crown leaves an opening for red weevil to come in. The smell of the wound can be detected by the female red weevil from a long distance. Should any damage be done to the palm on the crown or the stem, a solution of tar should always be at hand to cover all wounds and exposed cracks on the stem. Tar acts as a deterrent to the red weevil while it masks the sap-odour from the wound.

Any bleeding signs on the stem might indicate the presence of the stem-bleeding disease (page 106). Stem-bleeding could also occur due to other reasons such as, lightning, high fluctuating water table, excess of fertilizer added to soil. However, the causal agent should be identified and treated accordingly.

Estate sanitation

Keeping the estate tidy and clean not only improves its physical appearance but also serves to reduce pest incidence.

Fallen or collapsed palms should be immediately disposed of. Collapsed palms may be harbouring red weevil larvae and if the trunk is allowed to remain, red weevils may emerge to infest the healthy palms. Such palms should be burnt immediately. Fallen palms should not be left without disposal. They should be made use of, as rafters or firewood or in other ways (untreated coconut logs however are unsuitable for fence posts). Trunks, when they start to decay, offer ideal breeding grounds to black beetle. Similarly, decaying timber of any sort lying around in the estate. Heavy weed growth in an estate helps infestation by rats (page 99), bandicoots and porcupines. Weed control thus plays a role in pest control as well. Husk heaps should not be left in one place for a long time as rats breed among them.

Fires

Often fires are lit indiscriminately among the coconut palms and such fires could damage palms, predisposing them to disease. Thus special care should be taken when fires are lit in coconut estates.

Some important coconut pests (*e.g.* coconut leaf miner) have been brought under control with considerable effort by establishing a complex of natural enemies. It is necessary to realise that the fires lit at night can attract a considerable number of such beneficial insects destroying them. Thus night fires should be avoided as far as possible.

CHAPTER 17

INFLUENCE OF SOIL AND ENVIRONMENT ON COCONUT IN SRI LANKA

In terms of climate, the best environment for growing coconuts in Sri Lanka is found within the areas enclosed by the coconut triangle. However, coconut can be grown in a range of climates and soils of Sri Lanka indicating that the coconut palm is highly adaptable to a wide range of environmental conditions when compared with other major plantation crops such as tea and rubber. The following discussion deals with climate and soil and their impacts on coconut performance and yield in Sri Lanka.

Climate and its Influence on Coconut

The Coconut climate in general

(*a*) Latitude, Altitude and Temperature :—

(i) *Latitude*: Although coconut is known to flourish in the equatorial regions, *i.e.* within the latitude range of 10°N to 10°S, it is found to perform fairly well even in latitudes as high as 26°N (Assam in India) and 25°S (Dauphin in Madagascar).

(ii) *Altitude*: The coconut palm favours lower altitudes. The upper limit of altitude is believed to be about 750 m. Yet in rare instances and closer to the Equator, it is found to grow successfully at much higher altitudes — (*e.g.*, in Tanganyika at an altitude of 1350 m).

(iii) *Temperature*: It is characteristically a temperature-loving plant. Provided other conditions are satisfactory, an upper limit for temperature probably does not exist. The lower limit for economic production would be about 70°F.

The limits to altitude requirements are set by the latitude. Closer to the equator, *i.e.*, at lower latitudes, coconut tolerates higher altitudes than at places further away from the equator. For instance, in certain parts of Mysore State in India where the latitude is 15°N, coconut plantations are found at elevations of 600 m to 900 m, whereas Tabora in Tanganyika with a lower latitude of 7°S has coconut plantations established even at an altitude of 1350 m.

Temperature, on the other hand, sets the limit to both latitude and altitude. In fact, the interaction of latitude and altitude referred to earlier is the result of the palm demanding a temperature above a certain minimum. Higher altitudes are tolerated close to the equator than otherwise because for a given altitude the atmospheric temperature is generally higher close to the equator than further away. As long as a certain minimum temperature is ensured throughout the year, it appears that latitude and altitude are of no importance from the point of view of the coconut palm.

(*b*) **Rainfall**

A weather factor ranking equally important to the coconut palm as temperature is rainfall. Coconut does well over a very wide range of rainfall conditions. The lower limit of rainfall is determined by the moisture holding capacity of the soil and the presence of other sources of water supply such as neighbouring tanks which supply water through seepage, or a high water table. The lower limit of annual rainfall where coconut is reported to grow is in regions of Mysore State which receive an annual rainfall of only 50-62 cm. The upper limit of rainfall where coconut grows well is reported to be in Indonesia where good plantations exist with annual rainfalls exceeding even 450 cm.

The coconut palm being in an unique position as a perennial fruit bearer, the point to be emphasised with regard to rainfall is that it should be well distributed over the year so that long dry spells (which cause heavy immature nutfall and abortion of inflorescences in their primordial stages) do not occur.

(*c*) **Humidity**

The tropical environment in which the coconut palm flourishes is characteristically warm and humid. A mean relative humidity above 85 per cent is favourable to the growth of coconut.

High humidity inhibits transpiration and consequently reduces the uptake of nutrients. Moreover, high humidity predisposes the palm to fungal disease (*e.g.* bud-rot).

(i) Coconut plantations around Mount Banshao have suffered by the persistence of "bud-rot" in a severe form as a result of high humidity conditions prevailing throughout the year.

(ii) Leaf disease in Kerala (India) occur during the rainy months when the atmospheric humidity is high.

(iii) The incidence of premature decay of fruit in Sumatra is found to be due to high humidity.

(*d*) **Sunshine**

The importance of sunshine to the coconut palm cannot be overemphasised. The palm does not grow well under shade or in too cloudy regions. While cloudiness inhibits transpiration, sunlight "raises the temperature of the leaf surface and thereby promotes better activity in the tree and also helps in the synthesis of organic food materials by the leaf chlorophyll."

Sunshine sets an upper limit to rainfall. While well distributed high rainfall is favourable to the coconut palm yet too much rain invariably reduces the hours of sunshine and thereby can be injurious to the palm.

The "Coconut-Climate" and Coconut Culture in Sri Lanka

In Sri Lanka, coconut yields vary widely in different areas due to climatic differences.

Table 15 shows the yield variations and the climatic indices of certain areas selected for their possession of one or more climatological deficiencies affecting coconut production.

Chilaw District is known to be the best area for coconut in Sri Lanka. Therefore its climate can be considered fairly optimum for coconut in Sri Lanka.

Kurunegala District which comes a close second to Chilaw from the point of view of coconut yields is similar to Chilaw with regard to most climatic factors, except for the slightly high altitude and the high diurnal range of temperature characteristic of inland areas.

Kandy District climate is inferior to Chilaw as a result of altitude, high diurnal range of temperature and low temperature.

Puttalam District climate is satisfactory except for the poor rainfall conditions.

Galle District is unique for its high humidity. Being in the heavy rainfall belt, the number of hours of sunshine would be limiting.

Hambantota climate is satisfactory in all respects except for the very low rainfall and slightly high humidity.

Table 15. Coconut Yields and Climates of selected areas

District	*CLIMATE*						*Yield nuts acre*
	Latitude	*Altitude (feet)*	*Temperature*		*Humidity (Daytime) %*	*Annual Rainfall (inches)*	
			Mean	*Diurnal range*			
			F°	*F°*			
Chilaw	7°23′	100	80.7	11.5	74	78.6	2912
Kurunegala	7°28′	381	80.6	14.9	68	77.8	2605
Kandy	7°20′	1572	75.9	15.9	66	82.2	2502
Puttalam	8°02′	7	81.1	12.0	68	44.2	1555
Galle	6°02′	41	80.8	8.4	81	95.5	1395
Hambantota	6°07′	61	80.7	11.2	76	43.1	1242
Batticaloa	7°43′	9	81.4	11.5	71	68.2	1069

In Batticaloa, all climatic indices appear to compare favourrably with Chilaw, yet the yield is very poor. However, the distribution of rainfall in Batticaloa is very poor. All other districts referred to enjoy two rainfall peaks consisting of the South-West monsoon rains and the inter-monsoonal rains of October-November, whereas Batticaloa gets only North-East monsoon rains leaving more than half the year dry.

Within the latitude range of Sri Lanka (6°N - 9°N), the optimum climatic complex for coconut consists of a maximum altitude of 65 m above sea level, a mean daytime temperature of about 25°C a mean diurnal range of temperature of about 7°C, a mean daytime relative humidity not exceeding 75%, and an annual well distributed rainfall of about 190 cm.

High altitudes associated with low temperature and high diurnal range of temperature, high humidity and low or poorly distributed rainfall affect the palm adversely.

Influence of Weather On Coconut Crops

(*a*) **Seasonal Yield Variation**

(i) **Relative magnitudes of the harvests within the year**

Coconuts are generally harvested at two-monthly intervals. The relative magnitudes of the six picks within the year are shown in Fig. 60.

It is observed that the highest picks are the 3rd and the 4th, each amounting to about 22% of the total crop for the year; the second and fifth picks each amounting to about 16% come next in order of magnitude; the first and sixth crops are the poorest, each being about 11%.

This pattern of the relative magnitudes of the six harvests within the year is fairly regular. However, sometimes the South-West monsoon rains may be delayed, in which case the fourth pick will turn out to be better than the third. Or, it may happen that the January-February dry period might extend upto March or even as far as early April as it sometimes happens. Such a prolonged drought would cause the bunches that would have normally matured in May to dry up prematurely and fall. These fallen nuts will be counted against the second pick, resulting in the second pick being even higher than the third pick. Such deviations are however rare. Therefore for all intents and purposes the pattern shown would be a good guide.

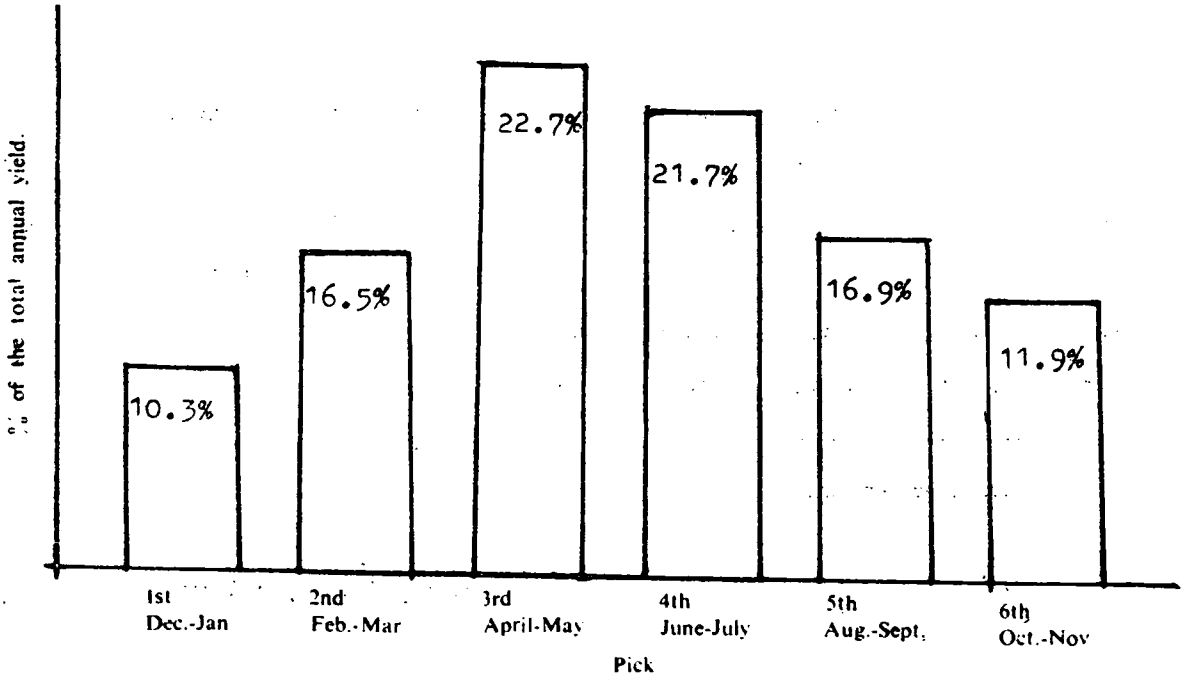


Fig. 60. Relative magnitude of the six picks within the year

Table 16. Progress of a Bunch of Coconuts

		Period of development				
	When spathe opens	*First 2 mths.*	*Second 2 mths.*	*Third 2 mths.*	*Fourth 2 mths.*	*Fifth 2 mths.*
Mean number of female flowers or nuts/100 bunches	1610	1230	580	550	540	530
% of nuts remaining in bunch	100%	76.2%	36.1%	34.2%	33.5%	33.1%
% nutfall within each 2-month period		23.8%	40.1%	1.9%	0.7%	0.4%

(ii) **Susceptibility of a developing bunch to immature nut fall**

The average progress of a bunch of coconut is as given in Table 16

It is observed that in the Intermediate Zone (rainfall 127—154 cm), when a spathe opens, it carries about 16 female flowers or potential nuts This drops to about 12 nuts within the first 2-month period, to about 6 nuts within the second 2-month period, to about five nuts during the 3rd 2-month period and thereafter immature nutfall is negligible Thus only about a third or less of the potential nuts remain up to maturity, the other two-thirds is lost through poor nut-set and immature nutfall

A further point of interest is that the highest immature nutfall (40 1%) occurs during the second two-month period, the next highest (23 8%) during the first two-month period and the third highest (1 9%) during the third two-month period, since the opening of the spathe

This shows clearly that the second two-month period since the opening of the spathe is the most susceptible period in respect of immature nutfall, the first two-month period is the second highest susceptible period and the third two-month period is the least susceptible Thereafter immature nutfall and consequently the susceptibility is negligible

(iii) **Period of moisture stress in the main coconut growing region.**

In the main coconut growing areas namely the N W P and Colombo District, the annual rainfall has two peaks, one constituting the South-West monsoon rains and the other the inter-monsoonal rains of October-November (see Fig 61) Consequently, there are two clearly defined dry periods in this region These are the periods January-February and July-August The period immediately following a dry period is a period of moisture stress in the palm Therefore in the main coconut region, the periods February-March and August-September can be considered periods of moisture stress likely to affect the palm in some form or other mainly by way of immature nutfall

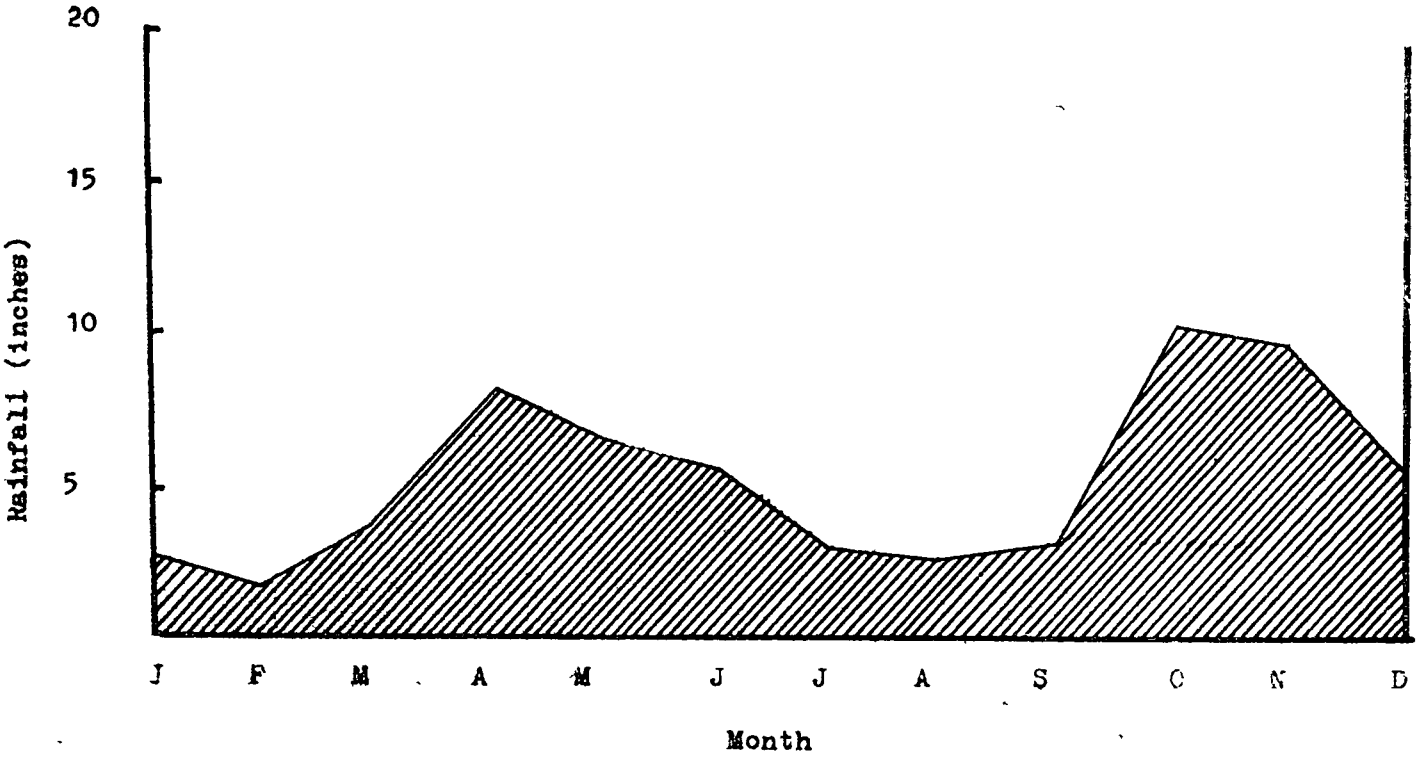


Fig 61 Rainfall pattern in the main coconut growing regions

Mature nutfall is another factor which though not classified as a crop component, is of no less importance to the coconut grower — specially the absentee land owner. Coconuts are harvested bi-monthly. Some bunches mature before the harvest and mature nutfall occurs before the pick.

These fallen mature nuts constitute a fluid fraction of the crop in the sense that the owner can lose them due to acts of omission and commission on the part of irresponsible elements without the owner being aware how much he has lost.

Mature nutfall can range from as much as one per cent to thirty-eight percent of the total crop. There is a fairly regular seasonal pattern in mature nutfall. The mean percentage mature nutfall in each of the picks (*i.e*, prior to the pick) is shown in Fig 62

The highest mature nutfall is in the fifth pick (September-October), the second highest is in the second pick (March-April) and the lowest is in the first pick (January-February).

From Fig. 62 it is clear that the highest mature nutfall follows the two dry periods of the year which are July-August and January-February Out of these two periods too, mature nutfall is higher during the period following July August, apparently because July-August being a dry period with longer day lengths when compared with January-February can be expected to bring about premature drying up of the nuts

Soils of Coconut Growing Areas and Their Impacts on the Coconut Palm

The soil structure of Sri Lanka is rather complex being composed of many soil-types Coconut-growing areas of Sri Lanka consist of several soil types of which a simplified picture is given in Fig 63

Soil types of the coconut-growing areas of Sri Lanka may be classified into seven major categories *viz.*, lateritic soils with and without hard pan, sandy soils, loamy soils, gravelly soils, alluvial soils, bog soils and the rock knob plain.

Lateritic soils and lateritic soils with hard pan (Red yellow podzolics with plinthite)

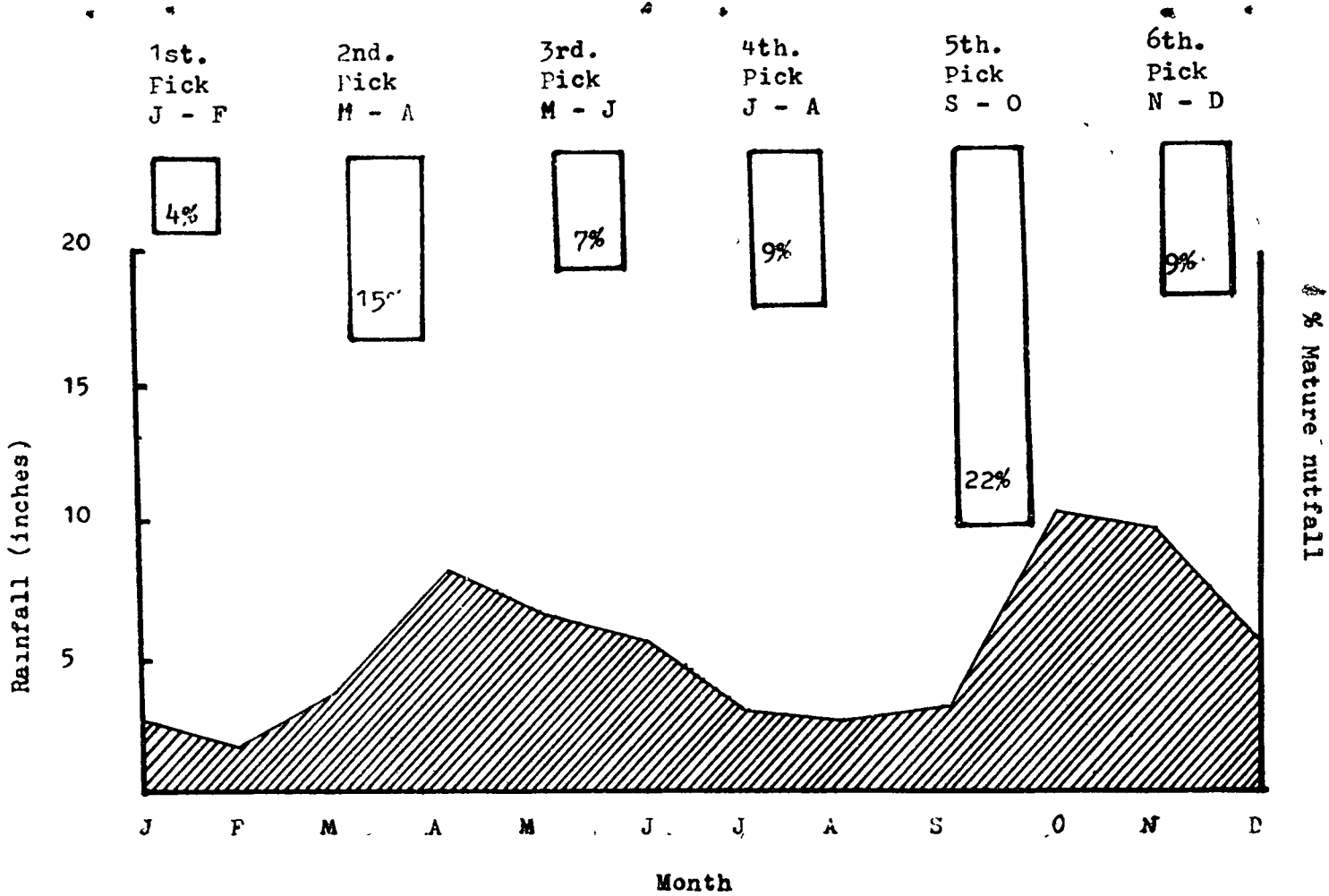


Fig 62 Mean percentage of mature nutfall

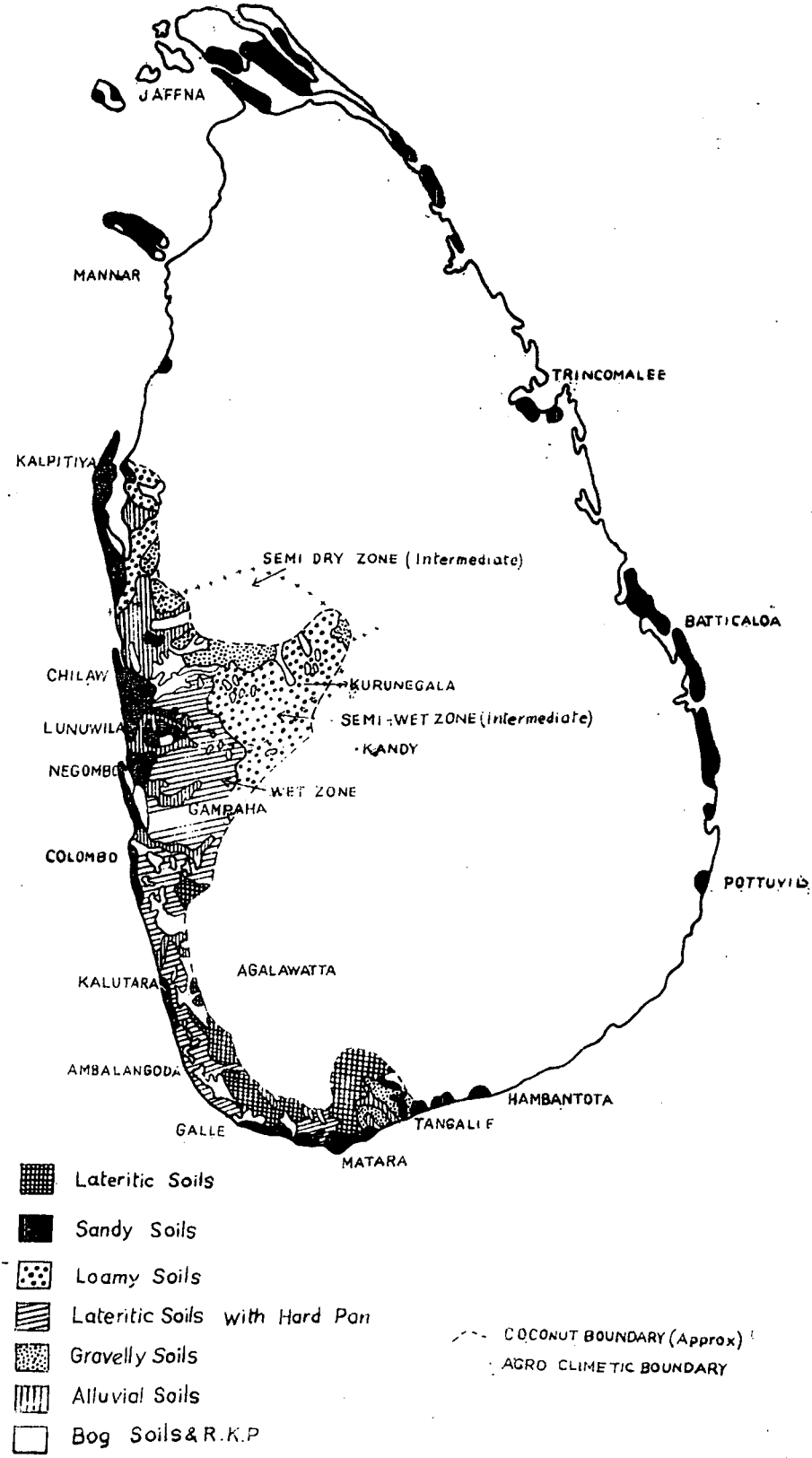


Fig. 63. Soil types of coconut growing areas.

Lateritic soils and lateritic soils with-hard-pan are similar in morphology. The former type is a deep soil while the latter may vary from being shallow to moderately deep. These soils contain gravel to a large extent and are well drained. Heavy leaking has taken place in these soils, thus they are low in fertility.

The percentage of clay in these soils is relatively low. More often than not these lands are undulating, hence soil erosion is a problem. Careful conservation measures for soil and moisture should therefore be adopted in such situations.

Phosphorus is less freely available to the palms as high phosphorus fixation takes place in these soils. The common acidic nature in such soils endures magnesium deficiency in coconut palms. As these soils are naturally poor in nutrients the nut yield can be rather low if no attention is paid to fertilizing. For instance, if no fertilizer is added for ten years in these soils, the nut yield can dwindle down as low as to 700 nuts per acre per year. However, up to 300 per cent increase (3000-4000) nuts per acre per year could be obtained with regular fertilizing on these soils. Thus the application of fertilizers is an essential practice in lateritic soils growing coconut to ensure a good yield.

Sandy soils (*Regosols*)

Sandy soils occur mostly along the coastal strips of the country. These soils are very poor in fertility and are very low in organic matter. They are very deep with a coarse texture providing good aeration to the roots and so offering ideal physical conditions for growth of the coconut palm.

Sandy soils are low in organic matter and the availability of nitrogen from ammonium salts in soil to the palm may hence be hindered. As heavy leaching of nutrients takes place in these soils, split application of fertilizer is always recommended. As the sandy soils in the Dry Zone receive less rainfall than those in the Wet and Intermediate Zones, phosphorus when added to soil should be added in a soluble form. Super phosphate is ideally suited for this purpose. In the Wet Zone phosphorus may be added to sandy soils as rock phosphate (Saphos phosphate).

Loamy Soils (Regosols and Red Yellow Podzolics without Plinthite).

Loamy soils offer ideal conditions for the growth of the coconut palm. These are very deep, well drained sandy loam soils with a fair proportion of clay and organic matter. Slightly reddish coloured loamy soils are the best suited for coconuts (*e.g.*, Marawila, chocolate loamy soil).

Loamy soils generally produce a good yield of about 3,000 nuts per acre per year even after ten years without fertilizer. However up to or more than 5,000 nuts per acre per year can be obtained if the palms are fertilized regularly.

Gravelly Soils (Reddish Brown Earths).

This soil type contains less gravel than the lateritic soils. These are well drained, moderately fertile soils but the physical conditions offered by these soils for coconut roots are poor.

Alluvial Soils

Alluvial soils are found close to rivers and rivulets. These are fertile soils but sometimes they are too clayey and heavy for coconut. The drainage and soil aeration is often poor owing to the high percentage of clay.

Bog Soils and Rock Knob Plain

Bog soils are poorly drained with high clay content. These soils are not suitable for coconut which needs good soil aeration and drainage.

In the rock knob plain, coconuts can not be grown successfully owing to the presence of large stones and shallow soil depths.

Variability of the Coconut Yield within Sri Lanka

The combined effects of climate and soil conditions influence the nut yield of the coconut palm. Some areas yield more nuts per unit area than other areas. The crop variation of coconut by Districts of Sri Lanka was discussed in Chapter 17 (See Table 15). The most favourable combinations appear to occur in a triangular area spread over the Western and North Western Province. This area is popularly known as the coconut triangle of Sri Lanka.

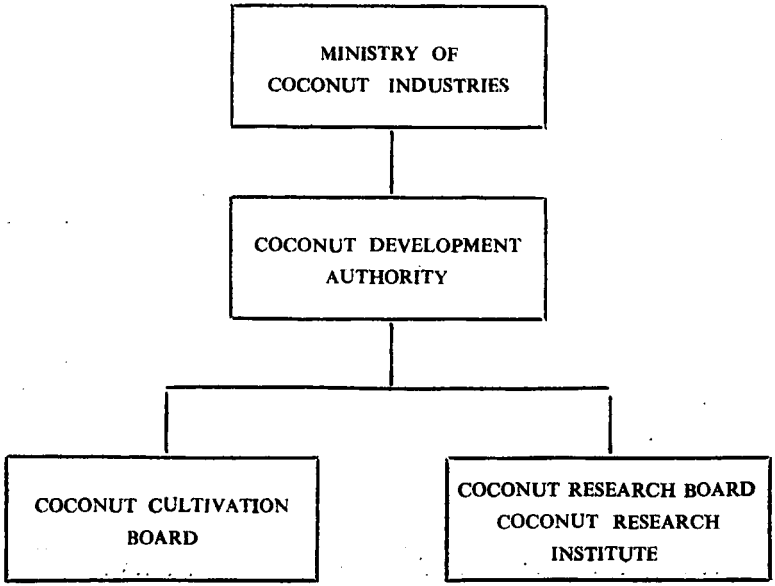
CHAPTER 18

ASSISTANCE OFFERED BY THE GOVERNMENT TOWARDS THE IMPROVEMENT OF THE COCONUT INDUSTRY OF SRI LANKA

Due to the vital importance of the coconut industry in the economy of Sri Lanka, the Government has instituted a separate Ministry to look after this plantation industry. The Ministry of Coconut Industries is solely responsible for overall development of Coconut Plantation Industry as well as its subsidiary industries associated with the processing of various products. Direction and supervision of the following Statutory Boards are under the Ministry.

(*a*) Coconut Development Authority
(*b*) Coconut Research Board
(*c*) Coconut Cultivation Board

ORGANIZATION OF COCONUT SECTOR



However, coconut growers are still not fully aware of the services rendered to them by these Boards. This Chapter deals with information regarding the assistance available to growers for the improvement of their coconut lands.

Supply of Planting Materials

Seedlings for new planting, under planting and replanting are made available by the Coconut Cultivation Board and the Coconut Research Board. Through this facility, the growers are in a position to obtain selected high quality seedlings for their requirements.

Limited numbers of seedlings of king coconut and other dwarf varieties are made available to the grower by the Coconut Research Board, Sri Lanka.

Coconut Seedlings supplied are of two major types *viz.*, the seedlings raised from nuts collected from high quality mother palms, (ordinary seedlings) and the seedlings raised from nuts obtained by controlled pollination. The latter are of two types :

1. Tall × Tall (also known as CRIC 60), and
2. Dwarf × Tall (also known as CRIC 65)

These seedlings are produced under expert guidance and supervision. The seedlings sold to the grower have been subjected to rigorous selection are therefore of high quality. Being heavily subsidised by the Government the selling prices of the ordinary, Tall × Tall and Dwarf × Tall seedlings are Rs. 3.00, Rs. 4.00 and Rs. 6.00 (ex-nurseries) respectively, although the cost of production of a hybrid seedling to the government is more than six times this selling price.

The tasks of collecting ordinary seednuts as well as obtaining nuts from controlled pollinations and the subsequent seedling production responsibilities, mainly of the Coconut Research Board. Depending on the pattern of monsoonal rains in the area, the Coconut Cultivation Board issues seedlings during two seasons. These are in May-June and in October-November.

The Coconut Research Nurseries raising seedlings of ordinary coconut, hybrid coconut, king coconut and dwarf coconut are located at Bandirippuwa Estate, Ratmalagara Estate and the Isolated Seed Garden at Ambakelle, Arachchikattuwa.

The grower is required to arrange the transport of the seedlings from the nurseries to his land Wherever rail transport facilities are available, arrangements are made by the Coconut Research Board for the despatch of seedlings by rail to the nearest railway station

Fertilizer Recommendations, Subsidies and Distribution

Research programmes are under way at the Coconut Research Board in order to elucidate the fertilizer needs of the coconut palms from time to time, fertilizer recommendations are revised based on new experimental findings

With a view to providing sufficient incentives to the coconut grower to fertilize his coconut land, the Government introduced the Coconut Fertilizer Subsidy Scheme in 1956 Coconut fertilizer since then has been available at 50 per cent of the actual cost However, until recently, the coconut grower did not have facilities to get financial assistance for purchasing of fertilizer The People's Bank and the Bank of Ceylon have now launched schemes for the coconut grower to obtain loans for the purchase of fertilizer on easy interest terms For this purpose, non-income-tax-payers are acceptable as guarantors The capital on these loans is repayable only after two years which will be about the time when the fertilizer applied gives returns The influence of fertilizer on nuts yields in a regularly fertilizer coconut land is appreciable and the repayment of the loan can be easily made by the increased returns from fertilizer application As a further incentive, fertilizer is now made easily available to the grower through a chain of fertilizer stores established throughout the island by the Coconut Cultivation Board There are Regional Coconut Fertilizer Stores at Ambalangoda, Batticaloa, Chilaw, Negombo, Kuliyapitiya, Kurunegala and Veyangoda In addition to these Regional Stores, other fertilizer stores are situated at Wariyapola, Galagedera, Mahayaya Estate,[1] Mohattawagoda Estate,[1] Mundel,[2] Thelijawila,[3] Johndale Estate,[1] Devivimana Estate (Beliatta) Coconut fertilizer is also available at several co-operative stores in the country, which are also afforded credit facilities

If the grower is doubtful as to the coconut composition of the fertilizer bought, an analysis of it may be obtained by sending a sample to the Coconut Research Board A reasonable charge will be levied for this

1 Kurunegala District
2 Puttalam District
3 Matara District

Subsidies to Rehabilitate Coconut Lands

Poor maintenance of soil and water lead to serious loss of crop (chapter 10) An outright non-repayable grant-scheme (subsidy scheme) for rehabilitating coconut lands is available to the grower from the Coconut Cultivation Board when the estate is over ½ acre in extent Subsidies are available for the following cultural and moisture conservation practiees

				Rate per Metre
1	Establishment of drains for the conservation of soil and moisture	On hard cabook soil	Rs	1 50
		On sandy soil	Rs	0 95
		On other soil types	Rs	1 25
2	Drainage drains			0 65

In addition to soil and moisture conservation measures, subsidies are also available for filling of vacancies and for removal of excess palms in the estate These are as follows

1	Filling of vacancies	Rs 3 25 per vacancy filled
2	Removal of palms in excess of 65 to the acre	Rs 20 00 per palm removed

A subsidy has also been introduced to enable growers to receive a grant for removal and replacement of unthrifty trees

Subsidies for Underplanting and Replanting of Coconut

Growers with ½ acre or more in extent with a minimum density of 15 palms per ½ acre has with palms over 60 years of age and an annual yield of less than 1000 nuts per acre per year (2470 nuts/ha/year) can get a grant of Rs 3000/- per acre for underplanting and replanting coconuts on their lands The grant is given in three annual instalments

	1st year	*2nd year*	*3rd year*
Under planting Rs	1200	900	900
Replanting Rs	1400	800	800

Subsidy for New Planting

To meet the daily increasing domestic demand for coconut and to arrest shrinking of the exportable surplus, more land has to be cultivated with coconut New lands of ¼ acre or more in

extent suitable for coconut can get a subsidy of Rs 3500/ per acre in three annual instalments as follows

		1st year	*2nd year*	*3rd year*
New planting	Rs	1600	900	1000

Subsidy for planting of coconut in Government Allotments or private holdings of 1 acre or less

Private owned holdings or land allotments of 1 acre or less in extent suitable for planting coconut are eligible for this subsidy provided that at least ten seedlings can be planted according to the recommended spacing (page) A grant of Rs 35 00 per palm will be paid to the grower in 4 instalments as follows

First instalment of Rs 15 00 within a month of planting and two instalments of Rs 10 00 in two succeeding years

The maximum number of plants for which this subsidy is available is 64 per acre

Subsidies on Pasture and Fodder establishment

The importance of growing intercrops under coconut to ensure optimum utilization of coconut lands was stressed in Chap ters and Owners of coconut land of ½ acre or more in extent, in areas with an evenly distributed rainfall of over 152 4 per year in Beliatta electorate and in the administrative districts of Colombo, Galle, Hambantota, Kalutara, Kandy, Kegalle, Kurunegala, Matale, Puttalam and Ratnapura are eligible to apply for a grant for establishing pasture and/or fodder on their coconut lands The value of the subsidy is Rs 800/- per acre paid in two instal-ments of Rs 400/- each

Subsidies for growing perennial crops

Owners of coconut lands of ½ acre or more in extent with a minimum of 30 coconut palms within the age group 20-45 years situated in areas with a rainfall of at least 177 8 cm per annum in the districts mentioned below can obtain a subsidy for estab-lishing coffee, cocoa and pepper under coconut

Crop	*Districts*
Coffee	Badulla, Colombo, Galle, Kandy, Kegalle, Kurunegala, Matale, Matara and Ratnapura
Cocoa	Badulla, Galle, Kandy, Kalutara, Kegalle, Kurunegala and Matale
Pepper	Badulla, Colombo, Galle, Kandy, Kalutara, Kegalle, Kurunegala, Matara, Ratnapura

Crop	*No of plants per acre*	*Subsidy(Rs) per acre*	*No of annual instalments*
Coffee	(360)	2125	3
Cocoa	(290)	2250	3
Pepper	(360)	2625	3

All subsidy schemes are handled by the Coconut Cultivation Board and application forms and other details regarding subsidies are available with the General Manager, Coconut Cultivation Board, Colombo 1 or at the offices of the Coconut Development Officers or at the regional in the area

Advice to growers

Trained advisory staff for advising the public on coconut growing and allied problems are available in all coconut growing areas in the country They are designated Coconut Development Officers of the Coconut Cultivation Board The Co-ordination of extension activittes on coconut in several areas is done by Assistant Managers in the regions Training of advisory personnel is carried out by the Coconut Research Board and Coconut Cultivation Board

Research in 'Coconut - Science'

All aspects of research pertaining to the improvement of the coconut palm and its agronomy are undertaken by the Coconut Research Board

Research into evolving new and promising varieties of coconut, utilization and improvement of coconut products, formulation of new coconut products, up-grading and assessment of

the control methods of pests and diseases all aspects of fertilizing of coconut surveying soils examining the suitability of pasture and other intercrops for coconut are some of the responsibilities of the Coconut Research Board directed towards the development of the coconut industry

Advice and assistance in Pest Control

Advice on pest and disease control is available to the grower from the Coconut Research Institute Any unusual damage to coconut should be notified early to the Director Coconut Research Institute Lunuwila giving information on the exact nature of damage the extent of the damaged area and directions regarding access to the affected land Wherever possible the growers are requested to send a sample of the damaged tissue in advance for examination

Breeding and releasing of parasites against the coconut leaf miner and the coconut caterpillar are being carried out by the Coconut Research Institute These parasites are posted free of charge to the growers in wooden boxes to be released on the affected coconut palms The cost involved in producing these parasites is quite high and therefore growers are requested to handle the glass tubes and the parasites contained therein very carefully The instructions given must be strictly adhered to In the case of any outbreak of a coconut pest a team of officers of the Coconut Research Institute equipped with necessary pest control apparatus offers help in the chemical control of the pest Such technical help and advice are given by the Coconut Research Institute free of charge It should be stressed here that most outbreaks can often be prevented if the growers are vigilant and inform the pest occurrence early to the Coconut Research Institute The decision as to the nature of the control method that should be adopted is made by the Coconut Research Board Where the use of an insecticide is found to be necessary its cost must be borne by the owner of the land Where possible free assistance in spraying etc will be made available by the Research Institute

Information on coconut

Several periodicals carrying information on coconut growing and other allied Research aspects are published by the Coconut Research Institute.

A popular Sinhalese Periodical named *Pol Pavat* is put out as frequently as necessary This is a publication sent free of

charge to local public and school libraries and agricultural organizations and on a subscription of Rs 2 00 per issue to others

Thirty seven leaflets carrying technical information on many aspects of coconut have been published by the Coconut Research Institute These are available on request

Ceylon Coconut Planters Review is another publication (in English) conveying the latest findings and recommendations in coconut growing to the growers in simple non technical language

Another quarterly publication is the *Ceylon Coconut Quarterly* This is a Research Journal published in English giving the latest advances in research and the experimental results of the Coconut Research Institute This publication is of a more technical nature and may perhaps not appeal to the small holder

APPENDIX

GUIDELINES FOR THE SAFE USE OF PESTICIDES

Insecticides, Herbicides, Fungicides

The pesticides most used by farmers fall into three major categories **insecticides, herbicides** and **fungicides** Insecticides are designed to kill insects, herbicides to kill weeds and fungicides to control plant diseases

Insecticides may be referred to as **animal poisons** whereas herbicides and fungicides may be described as **plant poisons** Because man belongs to the animal class, insecticides have the potential to poison him much more severely than do the herbicides and fungicides Thus insecticides are usually more toxic to man than the plant poisons

There are four classes of insecticides **organophosphates, carbamates, synthetic pyrethroids** and **organochlorines** All of them affect the nervous system

The organophosphate and carbamate insecticides become attached to the **cholinesterase enzyme** at nerve endings and speed up the flow of nerve messages The organophosphates, however form an **irreversible attachment** to the enzyme which, upon continuous exposure, can slowly lead to severe poisoning Daily exposures to low levels of organophosphates should be avoided

Some organophosphate insecticides are Hopper Spray Malathion, Diazinon, Spotton, Abate, Phosdrin, phosphamidon, Parathion, Thimet, Guthion

The carbamate insecticides, unlike the organophosphates, form a **reversible attachment** to the cholinesterase and therefore do not lead to slow poisoning. However, most of these are very toxic pesticides

Some carbamate insecticides are Temik, Sevin, Furadan, Lorsban

The cholinesterase enzyme is also found in the blood which can be collected and tested to determine your cholinesterase level

Herbicides and fungicides are designs to disrupt cell and plant growth—for example, some interfere with photosynthesis and root growth Since animals do not have these plant characteristics, herbicides and fungicides have moderate to low poisoning

potential to man A reasonably high amount of the pesticide may have to be absorbed into the body before any symptoms may be seen However, herbicides and fungicides may cause health problems many years later and should not be treated as though they are non-hazardous

Symptoms of Pesticide Poisoning

Because most insecticides affect the nerves, the symptoms produced are related to an **abnormal** functioning of the nerves The most commonly reported symptoms in their usual order of progression are headache, blurred vision, pin-point pupils, increased sweating, increased saliva, tears and breathing passage secretions More severe poisoning results in nausea, vomiting, changes in heart rate, muscle weakness, difficulty in breathing, mental confusion, and convulsions Symptoms of insecticide poisoning may begin almost immediately after exposure to the chemical Generally onset of most symptoms should occur before 12 hours after the termination of exposure

The symptoms of herbicide and fungicide poisoning may be due more to the hydrocarbon and kerosene solvents in the formulation than to the pesticide ingredient itself These symptoms resemble those of a flu and include itchy nose, eyes and throat, watery eyes, sneezing, and coughing, headache and nausea

First Aid Measures

If someone accidentally swallows a pesticide **do not** automatically assume you have to get the person to vomit Read the labelled under "FIRST AID INSTRUCTIONS" to determine whether or not to induce vomiting If the label recommends vomiting, **induce it at once by giving 15 millilitres (2 tablespoons) syrup of ipecac** If syrup of ipecac is not available, give the person plenty of water and stick your finger down the throat Salt water is no longer recommended as a method to induce vomiting because death may occur from salt overdose Get the person to a doctor immediately and take the labelled pesticide container with you

If the label does not recommend vomiting, **do not induce vomiting.** It is usually better to leave the chemical in the person's stomach rather than induce vomiting and risk the person's life Get medical attention as quickly as possible **Never induce vomiting or give anything to drink to an unconscious person.**

Many cases have been reported of people, especially children, being poisoned after drinking pesticides from soft drink bottles The obvious reason is that someone has transferred the chemical from its original labelled container to a pop bottle without a pesticide label

The number of accident poisonings can definitely be reduced if a few simple rules are followed —

— Always store a pesticide in its original labelled container,
— never eat or smoke after spraying until you have washed thoroughly,
— never use your mouth to clear a spray line or nozzle,
— store pesticides in a securely locked storage area

(1) **Recommended insecticides for Red Weevil**

The following systemic insecticides could be used as per the directions given on the containers

1 Metaystox 2 Azodrin 60 3 Nuwacron

(2) **Insecticides used as repellent agent for Black Beetle**

1 B H C dust

B H C dust should be mixed in the proportion of 1 4 with sand or saw dust and the mixture be placed inside the axils of palms

2 Aldrex 25

5 teaspoonful of Aldrex 25 mixed with 1 litre of water can be poured into the axils once in 6 weeks

(3) **Insecticides to control Termites**

1 Aldrin — This insecticide is available in the following trade names

i — Aldrin 25% E C — Chemical Industries Colombo Co (CIC)
ii — Aldrex 25 — Maharaja Organization
iii — Aldrex 25 E C — Lankem Lanka Ltd

2 Chlordane — This insecticide is available in the following trade names

i — Octochlor — Chemical Industries Colombo
ii — Intox 8 — Baur & Co Ltd
iii — Chlordox — Maharaja Organization
iv — Chlordane 45 E C — Lanka Petroleum Corporation