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MALAYSIAN RUBBER BOARD
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Processing Technologies

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Processing Technologies

Rubber Plantation and Processing Technologies

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FOREWORD

Malaysia's success in the natural rubber industry, among other things, has been mainly attributed to the strong support of R & D, good management, the availability of trained personnel and also the industrious workforce. In the early years, Malaysia was only known as the leading natural rubber producer, but now, Malaysia has also been acknowledged as a leader in the export of quality rubber products. Although the rapid industrialisation taking place in the country has somewhat obscured the role of the agriculture, rubber still holds a niche in the growing Malaysian economy. Whilst it is true that rubber areas are reducing, one will see that the number of factories for the manufacture of rubber goods is steadily increasing in tandem with industrial development; and becoming more and more important.

The RUBBER PLANTATION AND PROCESSING TECHNOLOGIES has been written with the sole aim to provide information and to serve as a text book on rubber for purposes of reference and practical utility. It is hoped that this integrated and self-contained book will meet a long felt need among students and exponents of the art and science of rubber production. Scientists and students interested in the natural rubber industry will also greatly benefit by becoming acquainted with the various activities and practices governing the production of rubber. This book has been based on currently available information and it has made extensive use of the immense experience of the scientists gained throughout the years while they were in service with the Malaysian Rubber Board (MRB).

Undoubtedly, this book will be invaluable to all those who are directly or indirectly involved in the rubber plantation sector. It is well documented with easy-to-read diagrams, charts and photographs, and is also useful as a reference to those who are in the extension service and personnel dealing with the production of rubber.

Books on natural rubber, inspite of its colourful and long history, are still considered few, and I strongly believe that this publication is aptly an addition that will share its days of glory both in the past and in the present. Last but not least I would like to congratulate the excellent job and tireless efforts of the team headed by the Director of Extension & Development Division who were entrusted with the task of adapting two earlier books written in Bahasa Malaysia and thereafter compiling the book.

Dato' Dr Kamarul Baharain bin Basir
Director General
Malaysian Rubber Board

PREFACE

Rubber planting in Malaysia has been and will continue to be an important agricultural undertaking. It is still needed to accommodate those who are already involved in this venture. Malaysia is not only a major producer, but also an important consumer of natural rubber. Moreover, during the last two decades Malaysia has been the centre for rubber technology generation. It is therefore justifiable as well as appropriate for Malaysia to continue planting and producing rubber. However, the planting industry must be further updated and modernised. Early crop maturity and maximising yield must be the main aim now. This means that the adoption of technologies particularly by the smallholders who form the backbone of the rubber production sector is continuously utilised and sustained. The natural rubber industry in Malaysia will continue to be one of the major contributors to the national economy and a source of pride for those directly involved in the industry, particularly, the smallholders and rubber planters.

This book is a revised adaptation of the two books written in Bahasa Malaysia entiled "Teknologi Getah Asli" and " Teknologi Perladangan dan Pemprosesan Getah" published in 1985 and 1994, respectively. It contains applicable technologies on rubber currently recommended and practised. There are ten chapters in all, out of which nine are technical. The first chapter provides an overview of the world natural rubber industry and an introduction to the Malaysian rubber industry. There are three sections consisting of glossary of terminologies found in this book, measurements and symbols.

In the presentation of this book, materials have been drawn from several other RRIM/MRB publications. To these writers we wish to offer our deepest gratitude. Most significantly the contributions from the scientists, specialists in their respective fields, are readily acknowledged and appreciated. In a work of this kind it is impossible to enumerate all those who provided advice or assistance. It will, however, be remiss not to acknowledge the admirable achievement of the team who were given the task of compiling this book and editorial advice given by Puan Rabeatun Awaliah Awalludin, Head of Publications and Library Unit. Thanks are also due to Dr. Mohd Akbar Md. Said, MRB Deputy Director General (Research & Innovation) for the time and trouble he has taken to read through the manuscript and for his invaluable suggestions and ideas in improving the compilation of this book.

Our great appreciation to the following for their contributions in making this publication possible: Tn Haji Abu Bakar bin Haji Ahmad (Original idea and draft), Dr. Othman bin Hashim (Coordinator), Pn V. Vanaja (Coordinator), Pn Masitah binti Arsad (Editing and Publishing), En Abd Latif bin Dalib (Administration), En Shahrir bin Mohd Salleh (Administration), En Azmi bin Din (Photography), En Ahmad Fadzil bin Ahmad Faiz (Typesetting), En Norzaid bin Kamarudin (Design input), En Azril Azmil bin Kamaluddin (Cover Design), Pn Haslira binti Khalid (Text Input), Unit Heads, Senior Officers and Staff of MRB (Inputs and updates).

Finally, our thanks to Dato' Dr. Kamarul Baharain Basir, Director General of the MRB, for his permission to publish and for writing its foreword.

We dedicate this book to all those who are involved in developing and upholding the rubber industry until the present time. They may be planters, smallholders, extension agents, supervision personnel and others. We urge and hope all of you will carry on the good work that you have put up thus far. With your commitment and concerted efforts the Malaysian natural rubber industry will continue to survive and be viable as a major contributor to the national economy for many years to come.

Tuan Mohamad Tuan Muda
Director Extension & Development Division

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CHAPTER 1

INTRODUCTION

Natural rubber (NR) is a major industrial raw material harvested from the rubber tree. Among the twenty odd plant species that are known to produce rubber, no less than twelve belong to the *Hevea* group. Out of these, only *Hevea brasiliensis* from the *Euphorbiaceae* family is economically exploited. The tree is a native of the Amazonian rain forest of South America. Hevea is a tropical crop that can survive within 1,000 km north and south of the equator, except for the arid regions. It requires 180-250 cm of rainfall per year and a temperature of 25-35 degrees Celcius. Rubber can be planted to a maximum elevation of 500 m above sea level. It requires a deep firm soil of the loamy texture with free drainage and tolerates a water table of 100 cm from the surface and below. The rubber tree is a perennial crop with an economic life-span of approximately thirty years. When fully matured, it can reach a height of 18-20 metres. Originally identified as a forest vegetation, *Hevea* wood is a valuable tropical timber which comes under the semi-hard category and most suitable for the furniture industry. Its latex, harvested from the tree, has been the major contributer to the NR industry towards the development of various rubber and rubber-based products.

Brief History

The existence of the rubber tree and its early crude product was internationally revealed as early as the Fifteenth Century, when Columbus discovered the Americas. Since then, raw rubber was taken to Europe from time to time. About 400 years later, several discoveries were made for its uses. Some of these earliest achievements were:

- 1768 – Discovery of rubber boots
- 1770 – The name “rubber” given by Priestley
- 1823 – Waterproof fabric by McIntosh
- 1839 – Vulcanisation process by Goodyear
- 1846 – Solid tyres by Hancock
- 1888 – Pneumatic tyres by Dunlop

The vulcanization process founded in 1839 was considered an important breakthrough in the development of the rubber industry, setting off its widespread planting. In 1876, some 70,000 seeds (later known as the Wickham's Collection) were taken from Brazil to the Royal Botanic Garden at Kew, England. In 1877, some of these seedlings were sent to Ceylon (now Sri Lanka), thirteen to the Singapore Botanic Garden and nine to Kuala

Kangsar. Perhaps this was how the rubber tree came to the East, and it is still believed that the rubber trees of today (in the East) originated from the Wickham's Collection.

Early research and development (R&D) work on rubber was carried out from the small number of trees in the Singapore Botanic Garden. It was later intensified by H N Ridley when he became its Director in 1888. The most important development work pioneered by him was the excision tapping method of extracting latex from the tree. This is considered as another breakthrough that triggered the beginning of organised rubber planting in the East. This large-scale planting started when the first rubber estate was established in Melaka in 1903. In Peninsular Malaysia, early research in rubber was carried out by the Department of Agriculture, but as from 1925 onwards it became the entire responsibility of the Rubber Research Institute of Malaya (Malaysia) (RRIM). The RRIM became synonymous with advances in the NR industry which had been a resource centre of new technologies for the other NR producing countries as well. The R&D function is now amalgamated, together with the Tun Abdul Razak Research Centre (TARRC) in the United Kingdom, under the Malaysian Rubber Board (MRB) which was established in 1998 with the merger of the RRIM, the Malaysian Rubber Research and Development Board (MRRDB) and the Malaysian Rubber Exchange and Licensing Board (MRELB). MRB was given the task to advance and sustain the viability of rubber industry through its R&D, technical support and regulatory functions encompassing the upstream, processing and downstream sectors.

World Rubber Industry

World production and consumption of rubber, both natural and synthetic continued to increase in 2007. Total rubber consumption in 2007 increased to 22.90 million tonnes *(Table 1.1)*. The growth rate in 2007 of 5.7% was the fastest pace in three years, *i.e.* the growth rates were 3.3% in 2006, 2.1% in 2005 and 5.9% in 2004. NR comprised 42.12% of total rubber production in 2007. Growth in 2007 was supported by the rapid increase in demand for rubber from countries within the Asia Pacific region and non-EU Europe. World natural rubber (NR) consumption rose to 9.71 million tonnes (5.4%) as compared to synthetic rubber (SR) consumption at 13.19 million tonnes (a growth rate of 6.0%). Global SR share increased to 57.7% mainly as a result of the increase of consumption in the Asia Pacific.

For NR, Asia has always been the main producer. In 2007, SR production increased to 13.32 million tonnes (4.4%). In contrast, due to weather problems, NR output was stagnant in 2007 at 9.7 million tonnes. Production in Thailand, Malaysia, India and Cambodia dropped in 2006 over 2007, but there were increases for Indonesia, Vietnam, China, Africa and Latin America.

TABLE 1.1 WORLD RUBBER PRODUCTION AND CONSUMPTION ('000 TONNES) 2000-2007

	2000	2001	2002	2003	2004	2005	2006	2007
Natural Rubber (NR)								
Production	6,762	7,328	7,332	8,033	8,748	8,882	9,680	9,685
Consumption	7,340	7,333	7,628	8,033	8,715	9,082	9,216	9,715
Synthetic Rubber (SR)								
Production	10,870	10,483	10,882	11,390	12,019	12,155	12,762	13,310
Consumption	10,830	10,253	10,692	11,371	11,839	11,895	12,446	13,188
All Rubber (NR + SR)								
Production	17,632	17,811	18,214	19,423	20,767	21,037	22,442	22,995
Consumption	18,170	17,586	18,320	19,404	20,554	20,977	21,662	22,903

Source: International Rubber Study Group (IRSG)

As for NR latex, there were declines in output in Thailand, Malaysia and India but increases were noted in China and Sri Lanka. But the net result indicated a shortage of supply against the increasing trend in demand. Hence, the sustained level of high prices of NR latex in 2007.

Malaysian NR Industry

The rubber industry has been a pillar of the Malaysian economy since 1950's and continues to be a major contributor until the present day. Though the planted area under rubber has been continuously declining since 1982, NR production remained at about 1 million tonnes since 2004; indicative of increased land productivity. The importance of NR in terms of socio-economy cannot be denied as it sustains the livelihood of more than 200,000 smallholder families while the downstream manufacturing sector provides employment to over 64,000 workers. This sector made a significant contribution to the economy with total export earnings from three sub-sectors grew from RM5.3 billion in 1990 to RM25.3 billion in 2007. Of this, export value share of rubber products stood at RM10.09 billion followed by rubberwood products at RM7.96 billion and natural raw rubber RM 7.21 billion. Thanks to the Government's favourable industrial policies, the rubber industry has over the years diversified from planting (upstream) into downstream manufacturing. Today, Malaysia is world's No. 1 exporter of NR gloves, catheters and latex thread.

Planted Area

NR planted area in 2007 was estimated at 1.25 million hectares, 183,000 hectares or 12.8% lower than the 2000's figure. During the period, both the smallholdings and estates sectors experienced decreases of 8.6% and 56.9% respectively *(Table 1.3)*. The declines reflected the conversion of rubber area to the more profitable alternative investment opportunities both within and outside the sector. According to the Rubber Industry Smallholders Development Authority (RISDA), the rate of replanting of rubber to other crops in the smallholdings in 2000 was 38,026 hectares. Of this figure, 98% was converted to oil palm. The rate of decline in planted hectarage has however decreased with the return of high prices, sustained at encouraging levels over several years since 2003. The other major NR producers, however, expand their rubber areas from 2000-2007 (*Table 1.2)*. This upward trend was led by Thailand with an increase of 492,000 hectares, followed by Vietnam (138,000 hectares), India (72,000 hectares) and Indonesia (42,000 hectares). Currently the smallholder sector accounts for 95.7% of the Malaysia's planted area while the balance is under the estates *(Table 1.3)*.

TABLE 1.2 AREA UNDER RUBBER IN MALAYSIA, THAILAND, INDONESIA, INDIA DAN VIETNAM ('000 HA)

Year	Malaysia	Thailand	Indonesia	India	Vietnam
2000	1,431	1,882	3,372	563	412
2001	1,389	1,956	3,345	567	416
2002	1,349	1,994	3,318	570	429
2003	1,315	2,019	3,290	576	441
2004	1,268	2,072	3,262	584	454
2005	1,259	2,175	3,279	598	483
2006	1,251	2,294	3,346	615	522
2007	**1,248**	**2,434**	**3,414**	**635**	**550**

Source: ANRPC; Monthly Bulletin
Department of Statistics, Malaysia

NR Production

Malaysia is the third largest NR producer, producing 1.2 million tonnes in 2007 after Thailand (3.1 million tonnes) and Indonesia (2.8 million tonnes) (*Table 1.4)*. Despite the shrinkage in planted area, production increased about 270,000 tonnes or 29.3% over 2000.

TABLE 1.3 PLANTED HECTARAGE OF NATURAL RUBBER ON ESTATES AND SMALLHOLDINGS IN MALAYSIA ('000 HA)

Year	Peninsular Malaysia		P.Malaysia Total	Sabah		Sarawak		Sabah & Sarawak Total	Malaysia Total		Grand Total
	Estate	Smallholding		Estate	Smallholding	Estate	Smallholding		Estate	Smallholding	
1998	175.60	1,107.51	1,283.11	4.10	85.90	0.22	170.29	260.51	179.92	1,363.70	1,543.62
1999	147.72	1,064.64	1,212.36	3.21	85.01	0.22	163.95	252.39	151.15	1,313.60	1,464.75
2000	121.16	1,063.79	1,184.95	2.40	85.01	0.22	158.10	245.73	123.80	1,306.90	1,430.68
2001	93.64	1,058.78	1,152.42	1.88	85.16	Nil	149.86	236.90	95.52	1,293.80	1,389.32
2002	84.28	1,054.86	1,139.14	0.53	62.89	Nil	146.25	209.67	84.81	1,264.00	1,348.81
2003	77.93	1,027.06	1,104.99	0.53	63.89	Nil	145.55	209.97	78.46	1,236.50	1,314.96
2004	64.22	993.11	1,057.33	0.20	64.57	Nil	145.90	210.67	64.20	1,203.58	1,268.00
2005	57.17	991.81	1,048.98	0.20	65.28	Nil	156.84	222.32	57.37	1,213.93	1,271.30
2006	54.04	988.55	1,042.59	0.11	65.28	Nil	155.61	221.00	54.15	1,209.44	1,263.59
2007	53.25	966.53	1,019.78	0.10	71.00	Nil	157.16	228.26	53.35	1,194.69	1,248.04

Sources: Statistics for planted areas in Sabah – figures provided by Lembaga Industri Getah Sabah (LIGS)
Statistics for planted areas in Sarawak – figures provided by Department of Agriculture Sarawak
The data for total rubber planted area in Malaysia estimated by Malaysian Rubber Board

TABLE 1.4 NR PRODUCTION OF MAJOR NR PRODUCING COUNTRIES ('000 TONNES)

Year	Thailand	Indonesia	Malaysia	India	Vietnam
1998	2,076	1,714	**886**	591	218
1999	2,155	1,599	**769**	620	262
2000	2,346	1,501	**928**	629	291
2001	2,320	1,607	**882**	632	313
2002	2,615	1,630	**890**	641	331
2003	2,876	1,792	**986**	707	364
2004	2,984	2,066	**1,169**	743	419
2005	2,937	2,271	**1,126**	772	482
2006	3,137	2,637	**1,284**	853	555
2007	3,056	2,755	**1,200**	807	602

Source: International Rubber Study Group (IRSG)
Department of Statistics Malaysia

TABLE 1.5 MALAYSIA'S NATURAL RUBBER PRODUCTION AND YIELD

Year	Estate		Smallholding		Total Production ('000 tonnes)	Average Yield (kg/ha/yr)
	Production ('000 tonnes)	Yield (kg/ha/yr)	Production ('000 tonnes)	Yield (kg/ha/yr)		
1998	198.87	1,330	686.83	906	885.70	970
1999	183.06	1,447	585.81	876	768.87	960
2000	128.13	1,289	799.47	1,184	927.60	1,226
2001	99.53	1,358	782.53	1,167	882.06	1,211
2002	84.88	1,361	804.95	1,211	889.83	1,237
2003	76.36	1,344	909.29	1,270	985.65	1,280
2004	71.23	1,372	1,097.50	1,296	1,168.74	1,300
2005	65.29	1,526	1,060.73	1,320	1,126.02	1,330
2006	68.40	1,584	1,215.24	1,358	1,283.63	1,370
2007	66.83	1,620	1,132.73	1,414	1,199.55	1,424

Source: Department of Statistics Malaysia

Table 1.5 shows NR production from 1998-2007 in the estates and smallholdings sectors in Malaysia. Total production in 2007 was 1.20 million tonnes, 94% of which was contributed by the latter. Average land productivity of the estates sector was 1620 kg/ha/yr while that of smallholdings was 1414 kg/ha/year. For the estates sector, output has persistently been on the declining trend despite the increase in yield; reflecting the considerable decrease in planted area. NR production in the smallholdings sector increased steadily after 2001 except for a marginal decline in 2007.

Among the factors for Malaysia's decline in rubber production are as follows:

- Wet weather conditions throughout the year
- Decreasing area under rubber
- Slow adoption of modern technologies, especially among the smallholders
- Some areas having overaged trees and abandoned
- Some replanted areas with high yielding clones are not yet in production

Domestic Consumption

Total domestic consumption of rubber (NR and SR) in 2007 was 579,248 tonnes (*Table 1.6*). This constitutes only about 2.5 % of the world total elastomer consumption. However, the above does not include the consumption of reclaimed and compounded rubber at 40,180 tonnes. Total NR:SR consumption ratio was 78:22. Trends indicated an annual increase in the consumption of SR since the 1990's.

Malaysia is the largest consumer of natural rubber latex and the fifth-largest consumer of NR in the world. Importation of NR continued unabated to supplement seasonal shortfalls in local raw material to sustain the latex- and rubber-based manufacturing industries. Sources of import are mainly from South East Asian producers. However, with the declining production trend coupled with substantial increase in local usage and price advantages, the pressure was on for greater raw material importation, especially for latex concentrate. In 2007, a total of 605,120 tonnes rubber were imported. Of all the suppliers, Thailand became the most dominant source of imports, from only 13,990 tonnes in 1991 to 421,480 tonnes (69.7%) in 2007.

Industry's Export Contribution

The Malaysian rubber industry is a RM25 billion industry in 2007. Export value contribution of rubber products stood at RM10.09 billion followed by raw rubber at RM7.21 billion. Rubber wood products contributed another RM7.96 billion mainly from the export of rubber wood-based industry (*Table 1.7*). Since 2001, rubber products and

TABLE 1.6 MALAYSIA'S RUBBER CONSUMPTION BY TYPE (TONNES)

Year	Natural Rubber		Synthetic Rubber		Total NR and SR			Total rubber
	Tonnes	% of World's	Tonnes	% of World's	Tonnes	NR:SR Ratio	% of World's	
1990	172,997	3.33	14,595	0.15	187,592	92.2:7.8	1.3	187,592
1995	307,750	5.13	44,145	0.48	351,895	87.5:12.5	2.3	351,895
1996	360,784	5.90	46,668	0.49	407,452	88.6:11.4	2.6	407,452
1997	360,188	5.57	48,857	0.49	409,045	88.1:11.9	2.5	409,045
1998	333,310	5.07	43,309	0.44	376,619	88.5:11.5	2.3	376,619
1999	344,447	5.18	57,587	0.56	402,034	85.7:14.3	2.4	402,034
2000	363,715	4.99	55,608	0.51	419,323	86.7:13.3	2.3	419,323
2001	400,888	5.46	57,699	0.56	458,587	87.5:12.5	2.6	458,587
2002	407,884	5.35	63,150	0.59	471,034	86.6:13.4	2.6	471,034
2003	421,781	5.47	66,452	0.58	488,233	86.4:13.6	2.5	488,233
2004	402,769	4.88	84,236	0.73	487,005	82.7:17.3	2.5	498,321
2005	386,472	4.42	96,417	0.81	482,889	80.0:20.0	2.4	494,582
2006	383,324	4.32	112,385	0.91	495,709	77.1:22:9	2.3	518,834
2007	450,246	4.62	129,002	0.98	579,248	77.7:22.3	2.5	619,428

Source: Department of Statistics Malaysia
International Rubber Study Group (IRSG).

rubber wood sub-sectors indicated continued increase in export contribution. NR sub-sector also registered an increase during the period except for a remarkable decrease in 2007 of RM1.0 billion or 12.5 % over 2006.

Rubber Products Industry

Only China, USA, Japan and India consume more rubber than Malaysia. The rubber products sub-sector contributes the highest in terms of export value. The composition of export contribution from this sub-sector is still skewed in favour of latex-based products at 75% in 2007 (*Table 1.8*). Tyre and inner tubes contributed about 9% followed by general rubber goods (8%) and other products categories at about four percent.

TABLE 1.7 EXPORT VALUE CONTRIBUTION OF THE MALAYSIAN NR INDUSTRY

Year	Natural Rubber (RM billion)	Rubber Products (RM billion)	Heveawood Products (RM billion)	Industry Total (RM billion)	% Contribution to National Export
2000	2.58	5.69	5.10	13.37	3.58
2001	1.88	5.71	4.59	12.18	3.65
2002	2.49	5.53	4.90	12.92	3.63
2003	3.58	6.06	5.37	15.01	3.86
2004	5.21	7.88	6.47	19.56	4.07
2005	5.79	8.03	7.25	21.07	3.95
2006	8.24	8.95	7.68	24.87	4.22
2007	7.21	10.09	7.96	25.27	4.18

Source: Department of Statistics Malaysia
Malaysian Timber Industry Board (MTIB)

Imports

Malaysia imports of raw rubber in 2007 increased to over 600,000 tonnes as compared to 512,000 tonnes in 2006. Of the total, latex is about 57 percent. Thailand is Malaysia's major source of imported rubber followed by Indonesia, Vietnam and the Philippines.

Since 2004, the industry imports approximately RM2 billion worth of rubber products mainly general rubber goods (GRGs) and tyres *(Table 1.9)*. Other imports included industrial rubber goods (IRGs), latex goods, footwear and inner tubes. The general trend has been that of annual increase in the imports of rubber products.

The large majority of companies involved in the production of industrial and general rubber goods are the small- and medium-scale enterprises (SMEs) comprising mainly of contract manufacturers to local and foreign companies. Strategic partnership and business alliances amongst some of the SMEs have led to improvements in production processes and technologies to enable them to move into the export market. In the highly labour intensive footwear industry, most locally-owned companies have relocated their operations in other countries particularly in the South East Asian region to capitalise on the relatively lower labour cost.

TABLE 1.8 EXPORT OF RUBBER PRODUCTS BY PRODUCT SECTOR (VALUE IN RM MILLION)

Year	Tyre	Inner Tubes	Footwear	Latex Products	Industrial Rubber Goods	General Rubber Goods	Industry Total	
							Value	% of National Exports
1990	210.59	22.89	111.49	1,346.48	21.72	163.50	1,876.67	2.4
1995	164.01	14.68	203.69	3,103.13	52.02	329.44	3,866.98	2.1
1996	191.84	16.14	188.13	3,393.67	61.31	336.92	4,188.02	2.1
1997	164.43	10.54	198.79	3,697.26	113.75	426.80	4,611.58	2.1
1998	321.63	15.80	211.79	5,260.10	198.37	483.43	6,491.12	2.3
1999	292.64	15.31	275.05	4,737.98	196.95	508.59	6,026.53	2.4
2000	243.89	13.56	301.97	4,498.84	130.04	497.23	5,685.55	1.5
2001	504.82	32.02	282.65	4,277.38	137.12	477.25	5,711.26	1.7
2002	418.20	34.00	209.84	4,335.46	62.01	465.67	5,525.17	1.6
2003	301.73	15.15	262.05	4,809.04	150.99	525.60	6,064.56	1.6
2004	413.65	18.10	857.42	5,818.37	188.88	580.19	7,876.61	1.6
2005	457.72	26.47	459.66	6,159.67	253.01	674.47	8,031.00	1.5
2006	552.15	22.76	370.20	6,956.18	320.98	729.55	8,951.83	1.5
2007	912.61	26.18	385.02	7,591.90	407.93	769.54	10,093.17	1.7

Source: Department of Statistics Malaysia

NR Prices

One significant difference in the rubber industry scenario currently is the protracted high NR price level over the last four to five years. The encouraging price is expected to sustain and this single factor impacts significantly on the livelihood of thousands of smallholder families. *Hevea* as a timber species becomes relatively the more attractive species to be planted as a plantation crop for timber production. A slow down in the conversion of rubber land to oil palm is expected and a there may be a return to rubber plantation by the private sector in locations where conditions are favourable to rubber planting, especially to the demarcated rubber zones.

TABLE 1.9 IMPORTS OF RUBBER PRODUCTS BY PRODUCT SECTOR (RM MILLION)

Year	Tyres	Inner Tubes	Footwear	Latex Products	Industrial Rubber Goods	General Rubber Goods	Total	% of National Imports
1990	31.42	1.40	18.34	36.55	53.93	122.78	264.41	0.3
1995	113.15	8.25	83.37	92.76	76.57	259.38	633.48	0.3
1996	92.02	8.39	102.78	99.74	83.07	286.65	672.65	0.3
1997	122.52	8.08	131.69	76.03	196.05	395.65	930.03	0.4
1998	64.96	5.55	70.03	127.79	185.93	368.77	823.03	0.4
1999	115.28	8.25	104.50	143.25	201.27	410.08	982.63	0.4
2000	190.46	9.46	160.64	171.53	199.15	460.84	1,192.09	0.4
2001	384.03	16.68	169.68	262.07	206.38	430.65	1,469.50	0.5
2002	478.13	10.90	207.44	162.81	168.28	442.58	1,470.15	0.5
2003	296.22	6.92	304.50	217.13	240.14	417.00	1,481.90	0.5
2004	436.56	7.77	543.43	252.60	315.58	525.23	2,083.16	0.5
2005	503.75	12.17	229.69	306.11	353.78	589.17	1,994.68	0.5
2006	623.82	21.99	317.00	330.79	418.31	646.02	2,357.94	0.5
2007	769.34	31.01	358.77	340.49	376.44	587.26	2,463.37	0.5

Source: Department of Statistics, Malaysia

Since 2003, the scenario for the NR upstream plantation sector has been one of encouraging prices for growers. This is a departure from the traditionally depressed and protracted low prices of the 1980's and 1990's. Changes in world trade and economy, especially with the China factor and an unprecedented increase in oil prices, had impacted favourably on NR prices. The tripartite cooperation amongst the three leading world producers of rubber, Thailand, Indonesia and Malaysia, has also, to some extent, resulted in positive sentiments to sustain prices at reasonably high levels. Prices have increased steadily since the end of 2001 from a low SMR 20 fob price of 183.5 sen/kg in December 2001 to a record high of 894.5 sen/kg in month of July 2006. Since 2005, prices still fluctuated but hovered over a higher band of between 443 sen/kg to 894.5 sen/kg and has breached the 1,000 sen/kg since June 2008. This higher band of prices has been sustained up to 2008 under present world economic scenario.

The latest development, in tandem with the rising price of crude oil, increasing production cost of SR and an increasing world demand for NR from the Asia Pacific regions has caused the price of rubber to surpass the RM 10.00/kg mark for SMR 20 in June 2008. The rubber producers are hoping the world's prices for NR will be sustained over a long period to spur a renewed interest in the rubber industry.

Industry Outlook

Upstream Sector

The rubber industry has gone through a significant structural change involving the smallholdings sector, which is less efficient in terms of rubber production compared to the estates sector. The former, which forms the backbone of the industry, is being given special attention. Smallholdings currently account for 95.7% of planted area and 94.4% of production. The average land productivity of the smallholdings sector in 2007 was 1,414 kg/ha/year compared to 1,620 kg/ha/year for the estates sector. The national yield average stood at 1,424 kg/ha/year in 2007. It is estimated that there will still be about 1.2 million hectare under rubber by the year 2010, of which 95% will remain as smallholdings. This area should be able to produce around 1.0 million tonnes annually provided that replanting programme is carried out at a targeted rate of 20,000 ha annually.

With reduced planted area and the need to maintain competitiveness, yield must increase *via* breeding, adoption of new latex harvesting technologies and sound agronomic practices. With better clones such as the Latex Timber Clones (LTCs), the national average yield should increase from 1,300 kg/ha a hectare to more than 1,700 kg/hectare. LTCs are capable of high yields in latex and timber, which provide the raw materials needed for the rubber and rubber wood product industries.

Clusters of smallholdings are encouraged to adopt new latex harvesting technologies under the low-intensity tapping system (LITS) concept while stimulation techniques to improve tree productivity, involving stimulation technologies such as *MORTEX* for young trees and gaseous stimulation for RRIMFLOW, REACTORRIM and *G-FLEX*, have to be introduced to offset the possible reduction in yield resulting from adopting LITS. The industry has been plagued by a shortage of labour, primarily skilled tappers causing severe reduction in national rubber production in early 2000 but the situation has been gradually recovered due to the present buoyant rubber price and the availability of foreign labour.

Midstream Sector

For the midstream sector, the Government is focusing on increasing the efficiency in the processing of rubber, production of specialty rubbers for niche markets and competitive environment-friendly processing techniques locally and overseas. R&D is being conducted to add value to rubber-processing factories' effluents, which can be used for biochemical extractions. This includes the introduction of environment-friendly processing technology to minimise effluent and waste discharges, and applications of bioprocess technologies to produce value-added product such as quebrachitol, which is a chemical feedstock for the synthesis of bioactive material.

Downstream Sector

There are three major product sub-sectors with potential for greater development which include: latex products, industrial and general rubber products and tyres. The service sub-sectors comprise testing and certification of rubber products. Malaysia has an edge over other countries in terms of its R&D facilities, manufacturing technology, product design innovations and marketing capability. MRB shall capitalise on its strengths to maintain the lead.

The rubber industry is expected to remain a strategic sector of the Malaysian economy even beyond 2020 if its diversification plans into higher value-added rubber products such as general (GRG) and industrial rubber goods (IRG) are any indication. The Government's support is the main driver of the industry's growth. The ongoing governmental efforts are aimed at strengthening the country's position as the leading manufacturer and exporter of latex products, expanding export markets for rubber products, building and retaining Malaysia's image as a supplier of quality rubber products and widening the present product range by developing the industrial and general rubber product sub-sectors.

In particular, MRB is intensifying its efforts to promote the Standard Malaysian Glove (SMG) programme for the premium medical gloves. The programme aims at production of quality gloves which in turn will enable the industry players to fetch remunerative prices. According to MRB, consumers can be assured that SMG-certified gloves are high in barrier performance, the lowest in protein and powder contents, superior in tactile sensitivity, high in strength besides being environment-friendly. A total of 30 glove companies were certified as SMG manufacturers in 2007.

Research and Development Focus

R&D is a crucial component that will provide an edge for Malaysian rubber products. MRB's R&D programmes have resulted in the development of high quality, technically-specified rubbers suitable for the manufacture of specialised rubber products. Meanwhile, at its technology centres in Sungai Buloh and Brickendonbury, United Kingdom, MRB is engaged in R&D to improve efficiency and productivity in the manufacture of high value-added products. Some potential R&D areas are in automotive rubber components, and development of NR for engineering, medical, military, sports and transportation. The private and public sectors should co-operate to develop rubber product manufacturing hubs and to spur growth as an approach to diversify the industry.

The 'green' rubber *Ekoprena* is an environment-friendly processed rubber that can be used as a component for many rubber-based products. On the other hand, biotechnology can provide a new source of growth to develop genetically improved rubber trees and manufacture of value-added products in pharmaceutical and medical sectors.

Latex Harvesting Technologies

In late 1980's, the LITS concept was introduced and recommended for commercial adoption by the NR industry because of low rubber production. Due to enumerative factors, large productive rubber areas were left untapped. The income from rubber tapping became very unattractive compared with other economic activities. Most rubber holdings and estate owners resorted to employing foreigners for tapping rubber trees. Latex harvesting technologies under LITS concept were introduced and recommended to the NR industry for addresing issues of shortage of tappers. These technologies offer numerous advantages which have been proven in R&D activities carried out by the MRB.

MRB has also introduced latex harvesting technologies for all ages of *Hevea* trees designed for increasing tree, tapper and land productivity and the income of tapper. Improvements have been made to the current conventional stimulation techniques based on feedback and continued R&D activities by MRB. The ethephon-based formulation *(MORTEX)* allowed more frequent applications which can be adopted from opening of tapping with more consistent high yield and minimal deleterious effect on the growth. The improved gaseous stimulation technique is characterised by more user-friendly gadgets and easier to operate and maintain devices. With relatively cheaper than other gaseous stimulation available in the market, this would encourage more smallholders to use this technique.

Rubber Forest Plantation for Timber Production

In ensuring adequate supply of raw materials for downstream activities, rubber trees have been bred for dual purposes; namely, for the production of latex and timber. In contrast to the 30-year conventional replanting and wood harvesting, the rubber plantation for timber concept spanning a 15-year life cycle has been adopted with latex production scheduled between five to seven years before rubber trees are felled for timber. Hence, there is a need to develop exploitation systems which can produce higher land productivity from opening of tapping and sustained over the scheduled exploitation period starting from the ninth year after planting. Early results from the non-LTC clones showed that there are promising exploitation systems which can produce up to 2,000 kg/ha/year. Irrespective of the purpose of rubber planting, appropriate and adequate agronomic inputs are required to ensure sustainable production.

With good rubber prices and support from the government who is encouraging the establishment of rubber plantation for wood extraction through the provision of financial and fiscal incentives, the industry envisions the setting up of rubber plantation for timber on a large scale. As land is limited in Peninsular Malaysia, more rubber plantation would be established in Sabah and Sarawak. Strategies and action plans to meet anticipated surge in demand for planting materials are needed and must be periodically reviewed parallel with changes in the rate of establishment of rubber plantation for timber. At the same time, advisory and extension services must be extended to interested investors who are unfamiliar with the management of plantation crops such as rubber.

Investments in rubber plantation for timber can be more attractive if the activity is fully integrated to take advantage of the attractive value-added revenue from downstream rubberwood processing and product manufacturing. Rubber plantation development is expected to be concentrated in Sabah and Sarawak in view of the huge concession areas that must be reforested with rubber as a timber species. Several saw-milling companies in East Malaysia have integrated upstream into the planting of *Hevea* in previously logged concession areas. The growth of rubberwood processing and rubberwood products manufacturing in Sabah and Sarawak could be a likely development strategy for the future. This reforestation programme will ensure adequate and uninterrupted wood supply while providing good margins from value-added processing.

It is in the long-term interest of the rubberwood-based manufacturers to take steps to ensure that their enterprises are not jeopardised by any raw material shortages. Rubberwood products, especially furniture, have received very favourable responses from the world market and much of the potentials for both the product and its markets have yet to be fully tapped. In this light, private sector manufacturers should have the foresight to invest in the future expansion of rubber plantation for timber. Malaysia still has the technical edge over other rubber producing countries as far as silviculture and agro-management of rubber trees are concerned. It has in stock some of the best bred species of rubber trees for plantation timber. Cognisance must be taken of these inherent advantages. The MRB as the custodian of the NR industry will continue to provide unrelenting support to all local parties involved in rubber forest planting activities.

Rubberwood Products

Growth of the rubberwood products manufacturing sub-sector continues to be encouraging amidst trends that indicate future shortage of rubber timber supply. Export revenue contribution from this sector overtook that of raw rubber since 1998 but fell behind in 2006 only on account of the unprecedented high raw rubber prices. Revenue from this sub-sector is expected to match that of rubber products in the near future. In 2007, its export value contribution at RM 7.96 billion constituted about one-third of the total export value contribution of the rubber industry (*Table 1.10*). Rubberwood furniture exports account for 67% of the total export value contribution. The remarkable growth of the Malaysian furniture manufacturing sector is very much supported by rubberwood which accounts for some 80% of export revenue from all species of wooden furniture.

TABLE 1.10 EXPORT VALUE CONTRIBUTION OF THE RUBBERWOOD PRODUCT SUB-SECTOR

Products	Export Value Contribution of Rubberwood Products							
	2000	2001	2002	2003	2004	2005	2006	2007
1.Sawntimber	0	87	92	60	137	386	70	55
2. Furniture	3,535	3,023	3,339	3,736	4,351	4,665	5,127	5,332
3. Mouldings	313	224	229	208	647	698	796	915
4. MDF	823	873	867	979	1021	1,107	1,145	1181
5. Chipboard	160	134	116	102	196	267	267	365
6. Builders' Carpentry & Joinery	269	243	261	281	110	116	103	102
7. Wooden Frames	-	-	-	-	12	13	12	13
Total	5,100	4,585	4,903	5,366	6,472	7,252	7,520	7,963

Source: Malaysian Timber Industry Board (MTIB)

Rubber Development Agencies

In Malaysia there are several rubber development agencies, each one with specific functions, such as R&D, plantation development, financing, marketing, supervision and coordination. *Table 1.11* lists out the various agencies involved and their functions.

TABLE 1.11 MALAYSIAN RUBBER DEVELOPMENT AGENCIES

Names of Agency	Functions
Ministry of Plantation Industries and Commodities	Coordination and supervision
Ministry of Rural and Regional Development	Coordination
Ministry of Natural Resources and Environment	Coordination and supervision
Ministry of International Trade and Industry (MITI)	Coordination and supervision
Ministry of Higher Education	Training development
Ministry of Finance	Supervision
Ministry of Agriculture and Agro-Based Industry	Training development
Rubber Industry Smallholders Development Authority (RISDA)	Planting development
Federal Land Development Authority (FELDA)	Planting development
Federal Land Consolidation and Rehabilitation Authority (FELCRA)	Planting development
Kelantan Selatan Development Authority (KESEDAR)	Plantation development
Terengganu Tengah Development Authority (KETENGAH)	Plantation development
Johor Tenggara Development Authority (KEJORA)	Plantation development
Pahang Tenggara Development Authority (DARA)	Plantation development
Lembaga Kemajuan Perusahaan Pertanian Pahang (LKPPP)	Plantation development
Lembaga Urusan Tabung Haji	Plantation development
Farmers Organisation Authority	Plantation development
Sabah Rubber Industry Board (LIGS)	Planting development
Sabah Land Development Board	Plantation development
Sabah Forest Development Authority (SAFODA)	Plantation development
Sarawak Land Development Board	Plantation development
Sarawak Land Consolidation and Rehabilitation Authority (SALCRA)	Plantation development
Department of Agriculture Malaysia	Training development
Department of Agriculture Sabah	Training development
Department of Agriculture Sarawak (JPS)	Training and planting development
State Land Development Boards of Peninsular Malaysia	Plantation development
State Economic Development Corporations of Peninsular Malaysia	Plantation development
Department of Forestry of Peninsular Malaysia	Plantation development
Department of Forestry Sarawak	Plantation development
Department of Forestry Sabah	Plantation development
Malaysian Rubber Development Corporation (MARDEC Berhad)	Processing and marketing development
Malaysian Timber Industry Board (MTIB)	Plantation development
Kuala Lumpur Commodity Exchange	Market development
Malaysian Rubber Export Promotion Council (MREPC)	Industrial promotion
Malaysian Industrial Development Authority (MIDA)	Industrial promotion

With such numerous agencies dealing in rubber-related development, the continuance of this industry in Malaysia is something which is economically feasible. What is actually required is commitment from those involved. Some of the measures suggested towards achieving the vision, are:

- Replacement of rubber with other crops should be prohibited unless the soil is proven unsuitable
- Replanting of smallholdings should, wherever possible, be carried out on group basis for more efficient management inputs
- Where possible rubber should be planted with other perennial crops to avoid dependence on rubber alone
- Provide some form of incentives, to attract the smallholders
- Ensure a more active role of the extension services machinery of the development agencies so that modern technologies are adopted to the maximum by the rubber growers

Sustaining the Malaysian Rubber Industry

The world's demand for NR will be on an increasing trend especially with the emergence of rapid development among Asian countries such as China and India and the upsurge in crude oil price which may favour increased consumption of NR as compared to the the synthetic rubber. Malaysia needs to stay competitive in the global market and among the reasons why Malaysia must continue planting and producing rubber are:

- Rubber is a strategic crop
- Rubber planting is a source of income for the smallholders who are now the major players in terms of production and hectarage under rubber
- It provides numerous job opportunities
- Rubber production also contributes to national income
- To supply the world's demand for natural rubber
- To supply Malaysia's own need for the raw material, rubber-based products manufacturing and timber industries of Malaysia
- To maintain Malaysia's position as one of the major NR producers
- To contribute towards greening the world for a cleaner and healthier environment

The prospect of NR industry is very promising in the near future due to its economic viability and sustainability which will continue to provide better socio-economic status to the smallholders. The good prices may encourage the younger generation smallholders to stay in rubber industry. Young graduates may involve themselves in the production process if it promises better income. This may be the beginning of a more educated and much younger smallholders wanting to move further into the production chain.

Currently, the government places greater focus on agriculture as a major engine of growth. Rubber will assume greater importance as a sector for economic expansion and income generation. As part of the national plans to make Malaysia a centre of excellence and a world leader in commodity-based industries, intensive efforts are on to improve the NR industry through education in plantation management, R&D and commercialisation of intellectual properties. It will be an integrated socio-economic entity that will ensure sufficient raw materials to sustain the requirements of the rubber processing, rubber products and rubber wood furniture sectors. The Malaysian rubber industry should grab this opportunity to produce more NR and gain maximum benefits from the current situation.

Henry Wickham (1876)
The natural rubber industry owes a great debt to
this specimen collector, explorer and trader

H.N. Ridley (1888)
He performed a one-man crusade persuading
planters to attempt cultivation of rubber

CHAPTER 2

DEVELOPMENT OF RUBBER CLONES

The rubber tree is just like any other living plant of the same category. It consists of the crown at the top which contains the branches and the leaves, the stem or trunk in the middle and the root system below ground.

The crown. The leaves grow on the leaf stalks, known as the petioles and connected by the petiolules. When the petiole falls off, a scar is left on the twig, branch or stem. The rubber tree defoliates its leaves annually, during the dry spell (January to March). This is known as wintering; the nature's way of preventing the water in the tree from being transpired through the leaves. The bud found between the petiole and the branch or stem is known as the axillary bud. The leaf scar left by the falling petiole also has a bud known as the scale bud. The bud that grows into a branch is known as latent, while the one that does not is called a dormant bud. At the very tip of the rubber plant there is also a bud known as the epical bud, which is ever-growing and forms the tree height.

The rubber tree is a flower-bearing tree. The flowers are of the inflorescence type, where both the males and females can be found. They are attached to the axis, the central and the sides. The female flowers are found only at the tip of the axis (central and sides) and the male flowers in the inflorescence. The male flower contains the anther and the pollen grains, while the female contains the stigma and the ovary. When the pollen grains enter the female flower through the stigma, fertilisation takes place. This is known as the pollination process. In rubber, the main agent for pollination is insects. Pollination produces fruits consisting of two to five seeds in each pod. The time taken from pollination to seedfall is approximately five months. Pollination can also be done manually and this is known as hand pollination. Hand pollinated seeds are usually required for breeding purpose. The whole outer hard cover of the rubber seed and fruit is purely made up of the female tissue. Although the formation of the fruit cannot occur without fertilisation, no male tissue enters it. The embryo which is found in the centre of the seed is the result of the union between the male and the female cells and inherits the characteristics of both. The embryo germinates and eventually grows into a tree. Seeds of a single mother tree (clone) exhibit visual characteristics that can be accurately identified.

The stem. The stem (also called as the trunk) consists of the central column known as the pith or medulla which is surrounded by the bark. The bark has three main layers, the outermost of which is the soft bast where latex-bearing vessels are found. Between the bark and the wood is the cambium, a soft thin layer, which by mitosis keeps a supply of new conducting pipes for the upward and downward streams, by producing new wood cells inwardly and new bast outwardly as the tree grows in size. The medullary rays are horizontally situated in the bark. Their functions are to supply water to the bark in one direction and food to the wood in the other direction. Latex, which is the economic yield of the rubber tree, is found in the latex vessels. It is a whitish milky fluid containing rubber hydrocarbon in the form of small globules floating in an aqueous solution containing proteins, amino acids, carbohydrates and various electrolytes. Latex is still considered a byproduct of the rubber tree, but a highly useful raw material to mankind.

The roots. The roots are part of the plant and are found in the soil. The rubber tree has three categories of roots. The tap root is the main central root that penetrates deep down the soil and keeps the rubber tree upright. The main and sub-laterals grow on it and provide anchorage to the tree. Feeder roots, which are numerous, grow on the laterals. Their functions are to absorb water by osmosis. At the tips of the feeder roots are the root hairs which absorb nutrient solution. The water absorbed by the feeder roots is forced into the central cylinder of the wood vessels and to the leaves. These remove the mineral food, retain water that is needed by the plant, and release the excess moisture through the stomata. The rubber tree takes in oxygen from the atmosphere through the stomata and lenticels, and gives out carbon dioxide as waste product of the respiratory process.

Desired Characteristics of a Rubber Tree

Rubber tree with desired characteristics will ensure its long term survival and at the same time will produce good yield throughout its economic life. It is important for the planters to have the knowledge on these desired characteristics as it will assist them when choosing good planting materials. The desired characteristics are:

- The tree has good vigour to ensure early maturity and production.
- Good girth increase when tapped, so that the stem is able to support the extended and heavy crown.
- The size of the leaves must be broad with shiny dark green colour to ensure of good food supply for the tree through photosynthesis.
- The main branches are well extended and growing upward to give balance to the crown.
- The side branches should be small and balanced, growing laterally and orderly to maintain balance and give lighter crown.

- The tree must be shady and not easily shaken by wind.
- The stem must be straight, smooth, well rounded and stood upright.
- The virgin bark is thick and smooth for easy tapping.
- The renewed bark is smooth, thick and quick to recover so that it can be re-tapped easily.
- High yielding; and during wintering the yield will be maintained without much reduction.
- Respond readily to yield stimulants.
- Once tapped the tree immediately exudes latex with good flow.
- When possible, the rate of tapping can be enhanced.
- The latex is stable and has high dry rubber content.
- The trees are not susceptible to diseases, wind damage and bark dryness.
- The tree must be suitable to be planted in all kind of environments.

It was found that all these desired characteristics are present in the existing rubber trees. However, not all of them were found in one tree. Further efforts are continued to produce a perfect rubber tree through breeding (*Figure 2.1*)

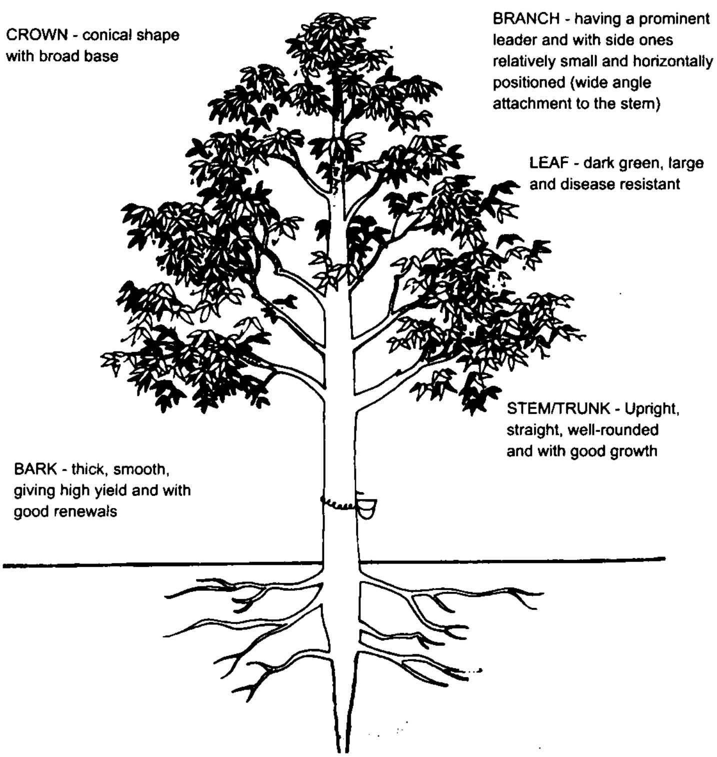


Figure 2.1 Profile of a perfect tree

PROPAGATION OF RUBBER

Propagation can be defined as efforts to produce, increase or multiply quality planting materials, so that they are always available when required. Like any other living plant, the rubber tree terminates its life, by death or destruction due to diseases, pests or natural calamity. Therefore, to ensure its replacement, propagation of that particular tree must be carried out. The rubber tree can be propagated by sexual and vegetative means.

Sexual Propagation

Sexual propagation produces offsprings which have variations in their characteristics. This means that their performances and capabilities are not guaranteed, although the mother tree itself may be perfect. Propagation by this method is done through pollination which can occur naturally or manually. The process involves the removal of the anther containing pollen grains from the male flower and putting it in the stigma of the female flower. Fertilisation takes place. Fruit and seeds are formed, which mature in about five months *(Figure 2.2)*.

a) Pollinating rubber flower

b) Rubber fruits

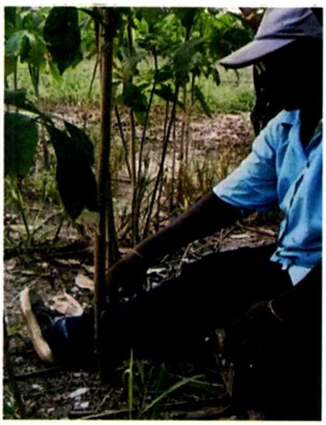
Figure 2.2 Hand Pollination Process

Vegetative Propagation

This method of propagation reproduces almost exactly the type of plant from where the propagated part is taken. In rubber, there are several propagation techniques, which can be broadly grouped into three, namely, cuttings, graftings and tissue culture. Among these, grafting is mostly preferred. Again, in grafting there are several options such as approach-grafting, cleft-grafting, root/seed-grafting and budgrafting. But budgrafting is the most popular as it is the simplest and guarantees higher grafting success. Budgrafting of rubber was first introduced in Sumatra in 1917 and is known as brown or conventional budding. From this, the green budding technique was developed in 1958. Further improvement on this led to the development of young budding in 1968. In this book, only the green and young budding techniques are described.

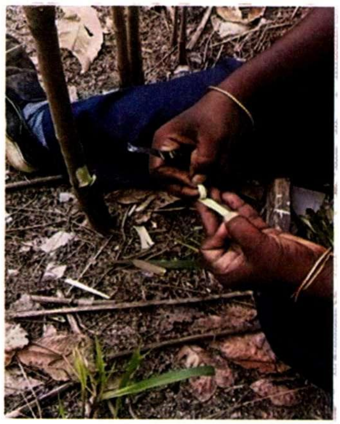
Green budding

One of the components for the green budding technique is the seedling stock of five to six months old, which can either be raised in polybags, ground nursery or open field. The stock should attain a stem size of 1.25 cm in diameter at the base. The other component is the bud which is taken from leafy green shoot of desired clones. To start budding operation, the base of the stock plant is wiped clean with a piece of cloth or rag. Two vertical cuts are made at the base of the stock stem, 7.5 cm high and 1 cm apart, and they are joined by a horizontal cut either at the upper or lower end. The bark is then stripped off either upward or downward depending on where the horizontal cut was made. The bark is cut away leaving 1 cm of tongue to hold the budslip in position later on. This operation creates an exposed budding panel of 6.5 cm x 1 cm. It is important that this exposed panel is not touched or allowed to be dirtied or left too long and became dry. A budslip of 10 cm in length is cut away from the budstick, including a thin slice of the wood. The bark is peeled off to remove the wood. It should be ensured that the inner side of the bark is not touched, dirtied, bent, bruised or exposed for too long. One end of the budpatch is then carefully slipped into the tongue of the budding panel, and the other extra end of the budpatch, which is already touched by the fingers, is trimmed off to fit into the budding panel, ensuring at the same time that the budpatch is not placed upside-down. The budslip is then firmly secured by tying a piece of transparent polythene tape of 16 mm x 0.05 mm. The budpatch should still be visible after this. Three weeks later, if the budpatch is still green (with callus formation around it), the budding operation is successful. The stock stem is cut-back at 10 cm above the bottom end of the budding panel and at the same time the polythene tape is removed. The scion shoot is expected to sprout in two to three weeks *(Figure 2.3)*.



a) Making vertical and horizontal cuts

b) Opening the flap



c) Stripping budpatch from budstick

d) Inserting budpatch into the "tongue"

e) Securing the budpatch using polythene tape

f) Completed budding process

Figure 2.3 Green budding process

Young budding

In the young budding technique, the seedling stocks are raised in polybags of 18 cm x 38 cm layflat dimensions. They should reach buddable size in about ten weeks with basal diameter of 6 millimetres. The buds used are also green but much younger in age and smaller in size than normally used in green budding. As usual, the base of the stock plant is cleaned. Two vertical cuts are made at the base of the stock plant 6 cm high and 0.6 cm apart, and joined by a horizontal cut at either the bottom or upper end. The bark is stripped off upward or downward depending on where the horizontal cut was made, and the bark is cut away leaving 1 cm of tongue to hold the budslip later on. This would expose a budding panel of 5 cm x 0.6 cm. Again, please ensure that this panel in not contaminated or left to dry. A budslip of 8 cm long is cut away from the budstick, including a thin slice of the wood. The bark is carefully

a) Making vertical and horizontal cuts

b) Opening the flap

c) Slicing the budstick

d) Stripping budslip

e) Inserting the budpatch

f) Securing the budpatch using polythene tape

g) Completed budding process

h) Successful budding process

i) Cut-back of stock stem

j) Scion shoot that has emerged

k) Polybags kept in the nursery

l) Ready for transplanting

Figure 2.4 Young budding process

peeled off to remove the wood. The same precaution must be taken with regards to the budpatch as described in the green budding operation. One end of the budpatch is then inserted into the tongue of the budding panel, while ensuring its position is not upside-down. The extra end of the budpatch already touched by the fingers is trimmed to fit into the budding panel. The budding can now be secured firmly by winding it around a transparent polythene tape of 16 mm x 0.05 mm in size. The budpatch should also be visible. Four weeks later, the budding can be inspected. A successful budding should have a budpatch which is still green with callus formation around it. The stock can be cut-back higher above the budding panel leaving two-leaf petioles on it to continue manufacturing food for the plant. All buds found on the stock snag must be removed by nicking to prevent them from sprouting. The stock can also be cut-back lower, leaving a much shorter snag as in the case of green budding, but this operation should be slightly delayed to a week or two to allow for the grafting to be hardened. In both cases the polythene strip binding the grafts must be removed. The scion is expected to appear in two to three weeks *(Figure 2.4)*.

PLANTING RECOMMENDATIONS

The MRB Planting Recommendations is updated every three years to provide information on the availability, status and performance of planting materials for the rubber planters. The MRB Planting Recommendations 2006 also follows the established format whereby the clones are recommended in two groups namely Group 1 and Group 2. However, Group 2 is further sub-divided into Group 2A and Group 2B to enable early selection among the newly recommended clones. Group 2A comprises all the clones, which showed good early performance in large-scale trials in different environments. All the newly recommended clones from the small scale trials are categorized in Group 2B as well as those clones which did not show good early performance in the various large scale clone trials. *Figure 2.5* shows the different stages of testing of the different group of clones.

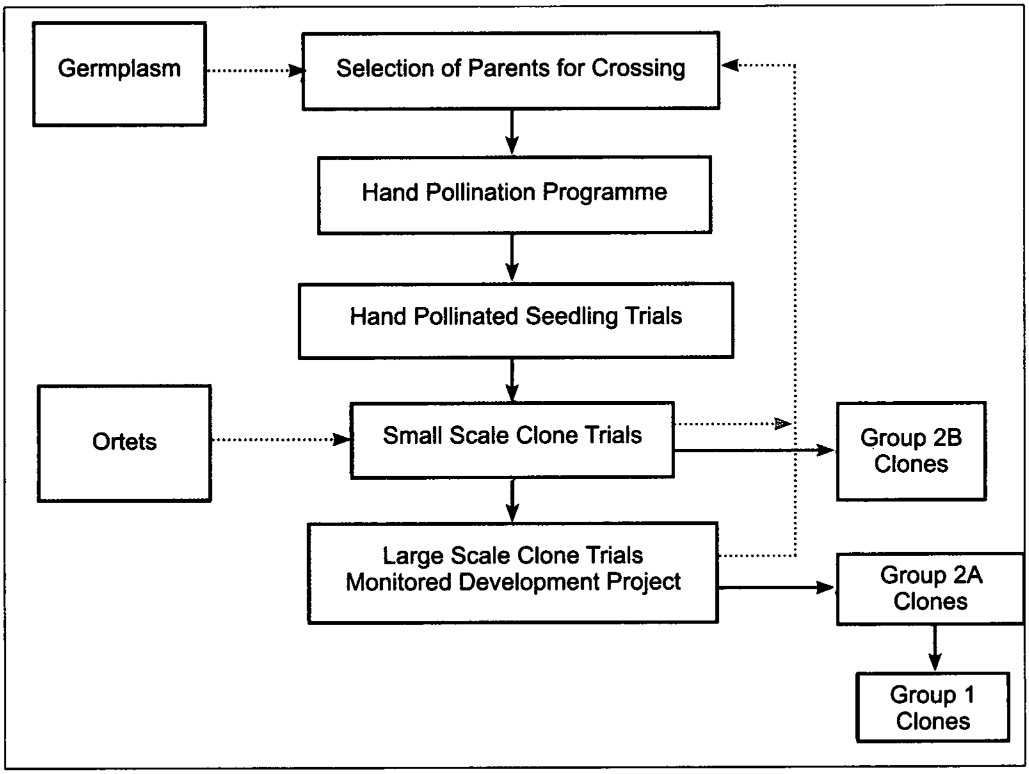


Figure 2.5 Flowchart showing the different stages testing different type of clones

The clones are further subdivided into latex-timber clones and latex clones in relation to their rubber and wood production as follows:

(i) Latex-timber clones (LTCs) are clones with high latex yield and rubberwood production. They exhibit good growth form such as good growth vigour and possess long straight boles. These clones are suitable for the production of latex and rubberwood or production of rubberwood only.

(ii) Latex clones are clones capable of producing high latex yield but relatively low rubberwood yield. These clones are suitable for latex production and not suitable for rubberwood production.

Group 1

Group 1 consists of clones with known track records based on at least five years of non-stimulated yield data on BO-I and two years in BO-II and also information on the secondary characteristics in large scale trials e.g. Large Scale Clone Trials (LSCT), Monitored Development Projects (MDP) or commercial planting. These clones are recommended for planting in estates and smallholdings without any restriction imposed on number of clones and size of planting. There are 14 clones of which ten are latex-timber clones and the rest are latex clones.

Latex-Timber Clones

The clones are: RRIM 908, RRIM 911, RRIM 921, RRIM 928, RRIM 929, RRIM 936, PB 260, PB 350, PB 355 and PB 359. The yield data of the newly upgraded clones RRIM 928 and RRIM 929 and the PB clones *viz.* PB 350, PB 355, PB 359 and PB 366, are obtained from various LSCT up to the eighth year in different environments. The eight years mean yield of these clones ranged from 1200 kg/ha/year to 1690 kg/ha/year using ½S d/3 6d/7 tapping system (*Table 2.1*). The mean yields of the other clones over ten years tapping are 1300 kg/ha/year, 1630 kg/ha/year, 1490 kg/ha/year and 1630 kg/ha/year for clones RRIM 908, RRIM 911, RRIM 921 and PB 260, respectively. Only clone RRIM 936 yields more than 2000 kg/ha/year, but it was tapped using ½S d/2 6d/7 tapping system. The relatively lower yields recorded for these clones as compared to their genetic potential were due to the lower number of tapping days *i.e.* about 70 tapping days per year.

Some of the important secondary characteristics of Group 1 latex-timber clones are resistances to wind damage (varied from average to very good) and to major leaf and stem diseases (ranged from severe to no infection) (*Tables 2.2 and 2.3*). Most of these clones also showed below average to very good with respect to other secondary characteristics. The estimated wood production between 19-22 years after planting, ranged from 0.74 m^3/tree in RRIM 928 and RRIM 936 to 1.59 m^3/tree in PB 355 (*Table*

TABLE 2.1 MEAN YIELD (KG/HA/YEAR) OF GROUP 1 LATEX-TIMBER CLONES

Planting material	Year of tapping										Mean
	1	2	3	4	5	6	7	8	9	10	
RRIM 908	929	1089	1491	1506	1561	1358	1395	1431	1193	1055	1301
RRIM 911	928	1464	1859	1799	1735	1668	1769	1841	1655	1599	1632
RRIM 921	960	1209	1518	1570	1709	1527	1565	1686	1684	1448	1488
RRIM 928	1249	1593	1644	1953	1336	1631	1641	1834	-	-	1610
RRIM 929	1005	1225	1445	1585	1368	1503	1396	1796	-	-	1415
RRIM 936*	1280	1800	2700	2670	2080	2690	2060	2220	2350	1610	2146
PB 260	1349	1641	1496	1569	1339	1841	1996	1886	1701	1124	1594
PB 350	1643	1552	1552	1898	1688	2191	2269	2102	-	-	1862
PB 355	723	1138	1146	1353	1241	1431	1403	1823	-	-	1284
PB 359	661	1083	1368	1507	1416	1499	1484	1538	-	-	1320

½S d/3 6d/7 tapping system
Data from Large Scale Clone Trials (LSCT)
Trees per hectare: 327 ± 34
* ½ S d/2 6d/7 tapping system

TABLE 2.2 SOME IMPORTANT CHARACTERISTICS OF GROUP 1 LATEX-TIMBER CLONES

Characteristic	RRIM 908	RRIM 911	RRIM 921	RRIM 928	RRIM 929	RRIM 936	PB 260	PB 350	PB 355	PB 359
Yield for first two years	4	4	4	4	3	5	4	5	2	2
Yield third to tenth years	3	5	4	NA	NA	5	5	NA	NA	NA
Wintering depression	4	2	3	3	3	3	4	4	4	4
Resistance to dryness	3	4	4	4	5	3	2	4	4	4
Resistance to wind damage	3	3	5	5	5	4	3	4	4	4
Vigour at opening	4	4	4	5	5	5	4	5	5	5
Girth increment during tapping	3	4	3	3	2	3	3	4	4	4
Virgin bark at opening	3	3	4	5	5	3	2	4	5	4
Renewed bark	3	3	3	5	5	3	2	3	4	3

5 = Very Good; 4 = Good; 3 = Average; 2 = Below Average; 1 = Poor, NA = Not available

2.4). The clear bole volume, measured from ground to the first persistent branch of the main trunk, ranged from 0.33 m^3/tree in PB 350 to 0.63 m^3/tree in RRIM 921. Generally, these clones have long, straight and smooth trunk characteristics.

TABLE 2.3 DISEASE SEVERITY OF GROUP 1 LATEX-TIMBER CLONES*

Characteristic	RRIM 908	RRIM 911	RRIM 921	RRIM 928	RRIM 929	RRIM 936	PB 260	PB 350	PB 355	PB 359
Pink disease (incidence)	N	N	N	N	N	N	L	N	N	N
Oidium	S	S	S	L	M	M	M	M	M	M
Colletotrichum	M	L	L	L	L	VL	M	VL	N	N
Corynespora	N	L	N	N	N	VL	N	N	N	N

N = Nil VL = Very light L = Light M = Moderate S = Severe
* Data from disease surveys and clone trials

TABLE 2.4 ESTIMATED WOOD VOLUME OF GROUP 1 LATEX-TIMBER CLONES

Planting material	Age (year)	Clear bole volume (m^3/tree)	Canopy wood volume (m^3/tree)	Estimated total wood volume (m^3/tree)
RRIM 908	22	0.51	0.51	1.02
RRIM 911	22	0.46	0.69	1.15
RRIM 921	22	0.63	0.63	1.26
RRIM 928	21	0.59	0.15	0.74
RRIM 929	21	0.60	0.60	1.20
RRIM 936	20	0.49	0.25	0.74
PB 260	20	0.37	0.92	1.29
PB 350*	19	0.33	0.83	1.16
PB 355*	22	0.53	1.06	1.59
PB 359*	20	0.42	1.05	1.47

*Data from Golden Hope Plantations Bhd. Clonal Trials at Prang Besar

TABLE 2.5 MEAN YIELD (KG/HA/YEAR) OF GROUP 1 LATEX CLONES

Planting material	Year of tapping										Mean
	1	2	3	4	5	6	7	8	9	10	
RRIM 938	1350	2220	3310	2310	1910	3460	1920	1930	2360	2150	2292
PB 280	1090	1500	1890	2180	2240	2160	2310	2310	2290	2260	2023
RRIM 901	1080	1710	2230	1980	2040	2990	2220	1720	1950	1790	1971
PB 366**	1215	1376	1539	1677	1601	1789	1529	1541	-	-	1533

Tapping System: ½S d/2 6d/7
No. of Tapping Days: 158 ± 11 days
Data from Large Scale Clone Trials (LSCT)
Trees per Hectare: 327 ± 34
** Yield from LSCT using ½S d/3 6d/7 tapping system

Some of the important secondary characteristics of Group 1 latex clones such as resistances to wind damage, varied from below average to very good, and to major leaf and stem diseases, ranged from severe to no infection (*Tables 2.6 and 2.7*). Most of these clones showed below average to very good with respect to other secondary characteristics.

TABLE 2.6. SOME IMPORTANT CHARACTERISTICS OF GROUP 1 LATEX CLONES

Characteristic	RRIM 901	RRIM 938	PB 280	PB 366
Yield for first two years	5	5	5	5
Yield for third to tenth year	5	5	5	NA
Wintering depression	1	3	4	4
Resistance to dryness	2	2	4	4
Resistance to wind damage	4	5	2	4
Vigour at opening	4	5	3	5
Girth increment during tapping	3	3	3	4
Virgin bark at opening	4	4	5	4
Renewed bark	3	4	5	3

5 = Very Good; 4 = Good; 3 = Average; 2 = Below Average; 1 = Poor

TABLE 2.7. DISEASE SEVERITY OF GROUP 1 LATEX CLONES*

Characteristic	RRIM 901	RRIM 938	PB 280	PB 366
Pink disease (incidence)	S	N	N	N
Oidium	M	M	M	M
Colletotrichum	M	VL	L	VL
Corynespora	L	N	N	N

N = Nil VL = Very light L = Light M = Moderate S = Severe
* Data from disease surveys and clone trials

Group 2

Group 2 consists of 33 clones comprising 9 clones in Group 2A and 24 clones in Group 2B. Due to limited information on the performance of these clones in different environments, planting of clones from this group should comprise basket of clones and not more than 50% and 20% are from Group 2A and Group 2B, respectively. These respective clones should be planted in blocks in accordance to recommendation.

Group 2A

Group 2A consists of new clones, which showed good early performance of at least three years yield data in large-scale trials in different environments. This would allow rubber growers to choose new promising clones in Group 2 with low risk. Group 2A comprises seven latex-timber clones namely RRIM 2001, RRIM 2002, RRIM 2007 RRIM 2009, RRIM 2015 RRIM 2016 and RRIM 2019; and two latex clones namely RRIM 2004 and RRIM 2005.

The five-year mean yields of the seven latex timber clones listed above, which were extrapolated from the Small Scale Clone Trials (SSCT) were 2850, 2350, 2710, 2280, 2760, 2580 and 2410 kg/ha/year, respectively. Whereas, the five year mean yields of the latex clones in the SSCT were 2467 and 2432 kg/ha/year, respectively, thus, indicating that these are potentially high yielding clones in the initial stage of testing. These clones were further tested in the LSCT in different environmental conditions throughout the country.

The three-year mean yields gram/tapping/tree (g/t/t) and kg/ha/yr of the seven latex timber clones from the LSCT are given in *Table 2.8*. Currently, only two trials had been tapped for three years. The other trials in different part of the country were established at a later date. Generally, the yield pattern increased from the first year to the third year tapping.

The mean yield in g/t/t ranged from 49 (RRIM 2002) to 74.20 (RRIM 2007) whereas, the mean yield in kg/ha/yr ranged from 1610 in RRIM 2016 to 28310 in RRIM 2007. The differences in mean yield based on g/t/t and kg/ha/yr were due to the number of stand. Except for RRIM 2007, all the other clones had relatively lower mean yields as compared in the SSCT. The yield of these clones is expected to increase further especially in the proceeding panels.

TABLE 2.8. MEAN YIELD (KG/HA/YEAR) OF GROUP 2A LATEX-TIMBER CLONES IN THE LARGE SCALE CLONE TRIALS

Planting material	Year of tapping						Mean	
	1		2		3			
	g/t/t	kg/ha/yr	g/t/t	kg/ha/yr	g/t/t	kg/ha/yr	g/t/t	kg/ha/yr
RRIM 2001	56.91	1191	50.54	1739	55.74	2045	54.40	1658
RRIM 2002	44.75	1102	51.94	1662	50.50	1732	49.06	1627
RRIM 2007	63.45	2045	77.54	3088	81.59	3360	74.19	2831
RRIM 2009	46.51	1342	49.01	1804	50.33	2005	48.62	1717
RRIM 2015	34.27	1050	50.85	1952	53.51	2191	46.21	1731
RRIM 2016	47.82	1152	57.20	1762	59.04	1921	54.69	1611
RRIM 2019	40.30	1295	49.05	2081	65.79	2905	51.71	2093

Tapping system: ½S d/3 6d/7
Average of two trials

The important secondary characteristics of these clones are summarised in *Tables 2.9, 2.10* and *2.11.* Most of the clones can be tapped at five years or earlier after planting. The clones showed high girth increment at immaturity, which ranged from 9.1 cm/year to 10.0 cm/year for RRIM 2001 and RRIM 2009, respectively (*Table 2.9*). Generally, these clones showed good tolerance to wind damage and nil to moderate infection of various diseases in field trials and nursery screening (*Tables 2.10 and 2.11*).

TABLE 2.9 MEAN GIRTH (CM) OF GROUP 2A LATEX-TIMBER CLONES IN THE LARGE SCALE CLONE TRIALS

Planting material	Year after planting				Mean girth increment (cm)
	2nd	3rd	4th	5th	
RRIM 2001	15.4	24.5	34.1	42.6	9.1
RRIM 2002	17.1	27.2	37.0	45.4	9.4
RRIM 2007	18.3	29.3	38.0	45.9	9.2
RRIM 2009	15.9	29.7	37.0	46.0	10.0
RRIM 2015	18.9	30.2	40.1	46.8	9.3
RRIM 2016	17.7	28.9	38.7	47.4	9.9
RRIM 2019	17.5	29.5	39.4	45.2	9.2

Average of two trials

TABLE 2.10 SOME IMPORTANT CHARACTERISTICS OF GROUP 2A RRIM 2000 SERIES LATEX-TIMBER CLONES

Characteristic	RRIM 2001	RRIM 2002	RRIM 2007	RRIM 2009	RRIM 2015	RRIM 2016	RRIM 2019
Yield for first two years	5	5	5	5	5	5	4
Resistance to wind damage	4	4	4	4	4	4	4
Vigour at opening	5	4	5	4	4	4	4
Virgin bark at opening	5	4	4	4	4	4	4

5= very good; 4 = good; 3 = average; 2=below average; 1=poor

TABLE 2.11 DISEASE SEVERITY OF GROUP 2A RRIM 2000 SERIES LATEX-TIMBER CLONES IN MONITORED DEVELOPMENT PROJECTS

Characteristic	RRIM 2001	RRIM 2002	RRIM 2007	RRIM 2009	RRIM 2015	RRIM 2016	RRIM 2019	RRIM 2020
Pink disease (incidence)	L	N	N	N	N	L	N	L
Oidium	M	M	L	M	M	M	L	M
Colletotrichum	M	L	M	M	L	M	M	M
Corynespora	L	N	L	L	L	L	N	L
Phytopthora	N	N	N	N	N	M	M	S

N = Nil VL = Very light L = Light M = Moderate S = Severe

The estimated wood volume of the Group 2A latex-timber clones at the age of 14-17 years after planting ranged from 0.60 to 1.28 m^3/tree for RRIM 2007 to RRIM 2015, respectively (*Table 2.12*). Most of these clones showed high wood production. The bole wood volume, which is the premier wood, was also high ranging from 0.20 to 0.44 m^3/tree.

TABLE 2.12 ESTIMATED WOOD VOLUME FOR GROUP 2A LATEX-TIMBER CLONES*

Planting material	Age (years)	Clear bole volume (m^3/tree)	Canopy wood volume (m^3/tree)	Total wood volume (m^3/tree)
RRIM 2001	17	0.41	0.82	1.23
RRIM 2002	17	0.44	0.66	1.10
RRIM 2007	14	0.20	0.40	0.60
RRIM 2009	14	0.34	0.34	0.68
RRIM 2015	14	0.43	0.87	1.30
RRIM 2016	14	0.43	0.85	1.28

* Estimated wood volume from Small Scale Clone Trials (SSCT)

The two latex clones in Group 2A showed high mean yields after three years tapping with 2280 kg/ha/yr and 2030 kg/ha/yr for RRIM 2004 and RRIM 2005, respectively (*Table 2.13*). The important secondary characteristics of these clones are summarised in *Tables 2.14, 2.15 and 2.16.* These clones showed good girth increment at immaturity. Except for severe infection of *Colletotrichum* in RRIM 2005, these clones showed good tolerance to wind damage and nil to moderate infection of various diseases in field trials and nursery screening.

TABLE 2.13 MEAN YIELD (KG/HA/YEAR) OF GROUP 2A LATEX CLONES IN THE LARGE SCALE CLONE TRIALS

Planting material	Year of tapping						Mean	
	1		2		3			
	g/t/t	kg/ha/yr	g/t/t	kg/ha/yr	g/t/t	kg/ha/yr	g/t/t	kg/ha/yr
RRIM 2004	49.57	1085	70.23	2343	89.35	3362	69.72	2263
RRIM 2005	65.79	999	77.69	2049	104.32	3045	82.60	2031

Tapping system: ½S d/3 6d/7
Average of two trials

TABLE 2.14 MEAN GIRTH (CM) OF GROUP 2A LATEX CLONES IN THE LARGE SCALE CLONE TRIALS

Planting material	Year after planting				Mean girth increment (cm)
	2nd	3rd	4th	5th	
RRIM 2004	15.5	26.0	35.0	41.9	8.8
RRIM 2005	16.4	25.9	35.0	41.9	8.5

Average of two trials

TABLE 2.15 SOME IMPORTANT CHARACTERISTICS OF GROUP 2A LATEX CLONES OF RRIM 2000 SERIES

Characteristic	RRIM 2004	RRIM 2005
Yield for first two years	5	5
Resistance to wind damage	4	4
Vigour at opening	4	4
Virgin bark at opening	4	4

5= very good; 4 = good; 3 = average; 2=below average; 1=poor;

TABLE 2.16 DISEASE SEVERITY OF GROUP 2A LATEX CLONES OF RRIM 2000 SERIES IN SMALL SCALE CLONE TRIALS

Characteristic	RRIM 2004	RRIM 2005
Oidium	M	L
Colletotrichum	L	S
Corynespora	L	N

N = Nil L = Light M = Moderate S = Severe

Group 2B

Group 2B consists of newly released clones, which are promising in the preliminary trials. These clones are selected based on five years yield data and other secondary characteristics from trials in limited scale such as SSCT. The performances of these clones in different micro-climates, soils and environments are not yet available. Area of one hectare or less should be planted with Group 1 clones or together with a basket of clones with not more than 20% of Group 2B which comprises 10 latex timber clones and 14 latex clones.

Latex Timber Clones

The latex timber clones are RRIM 2008, RRIM 2014, RRIM 2020, RRIM 2023, RRIM 2024, RRIM 2025, RRIM 2026, RRIM 2027, RRIM 2028 and RRIM 2033. The three year mean yields of RRIM 2008, RRIM 2014 and RRIM 2020 in LSCT were generally low with 1030 kg/ha/yr, 1380 kg/ha/yr and 1650 kg/ha/yr, respectively (*Table 2.17*). Yield data from the other latex timber clones in Group 2B are still not available. The mean yields of these clones were therefore extrapolated from the SSCT. The five year mean yields ranged from 2007 kg/ha/year for RRIM 2014 to 3040 kg/ha/year for RRIM 2027 (*Table 2.18*).

TABLE 2.17 MEAN YIELD (KG/HA/YEAR) OF GROUP 2B RRIM 2000 SERIES LATEX-TIMBER CLONES IN THE LARGE SCALE CLONE TRIALS

Planting material	Year of tapping						Mean	
	1		2		3			
	g/t/t	kg/ha/yr	g/t/t	kg/ha/yr	g/t/t	kg/ha/yr	g/t/t	kg/ha/yr
RRIM 2008	28.98	786	32.79	1082	36.79	1236	36.52	1034
RRIM 2014	19.01	720	34.28	1526	41.84	1886	39.08	1377
RRIM 2020	36.33	1083	46.92	1796	51.30	2057	44.85	1645

Tapping system: ½S d/3 6d/7
Average of two trials

TABLE 2.18 MEAN YIELD (KG/HA/YEAR) OF GROUP 2B RRIM 2000 SERIES LATEX-TIMBER CLONES IN THE SMALL SCALE CLONE TRIALS*

Planting material	Year of tapping					Mean
	1	2	3	4	5	
RRIM 2023	1989	2976	3480	2825	2848	2822
RRIM 2024	1509	2802	2828	3482	3158	2685
RRIM 2025	1921	2915	3174	2793	2967	2700
RRIM 2026	1450	2075	2172	3118	2410	2204
RRIM 2027	2381	2447	3349	3526	3477	3036
RRIM 2028	1695	1851	2836	2577	3201	2432
RRIM 2033	1442	1486	2402	2930	2306	2114

* Extrapolated yield from Small Scale Clone Trials (SSCT)

All the clones showed good secondary characteristics and the various disease severity on the clones ranged from moderate to no infection (*Tables 2.19 and 2.20*). Only RRIM 2026 showed severe infection of *Colletotrichum*. The girth increment before tapping and during tapping of these clones ranged from 8.5-10.7 cm/year and 2.5-7.6 cm/year respectively. The timber production for these clones ranged from 0.60 to 1.87 m^3/tree at the age of 14 to 16 years old in the SSCT. Whereas, the bole volume of these clones ranged from 0.20 to 0.66 m^3/tree (*Table 2.21)*

TABLE 2.19 SOME IMPORTANT CHARACTERISTICS OF GROUP 2B RRIM 2000 SERIES LATEX-TIMBER CLONES

Characteristic	RRIM 2008	RRIM 2014	RRIM 2020	RRIM 2023	RRIM 2024	RRIM 2025	RRIM 2026	RRIM 2027	RRIM 2028	RRIM 2033
Yield for first two years	5	5	4	5	5	5	5	5	5	5
Resistance to wind damage	4	4	4	4	4	4	4	4	4	4
Vigour at opening	5	4	4	5	5	5	5	5	5	5
Virgin bark at opening	4	4	4	4	4	5	4	5	4	4

5= very good; 4 = good; 3 = average; 2=below average; 1=poor

TABLE 2.20 DISEASE SEVERITY OF GROUP 2B RRIM 2000 SERIES LATEX-TIMBER CLONES IN MONITORED DEVELOPMENT PROJECTS

Characteristic	RRIM 2008	RRIM 2014	RRIM 2020	RRIM 2023	RRIM 2024	RRIM 2025	RRIM 2026	RRIM 2027
Pink disease (incidence)	L	N	L	N	N	N	N	N
Oidium	M	M	M	L	L	L	M	VL
Colletotrichum	M	L	M	M	M	M	S	VL
Corynespora	L	N	L	N	N	N	N	N
Phytopthora	N	N	S	N	N	N	N	N

N = Nil VL = Very light L = Light M = Moderate S = Severe

TABLE 2.21 ESTIMATED WOOD VOLUME FOR GROUP 2B LATEX-TIMBER CLONES*

Planting material	Age (years)	Clear bole volume (m^3/tree)	Canopy wood volume (m^3/tree)	Total wood volume (m^3/tree)
RRIM 2008	14	0.33	0.99	1.32
RRIM 2014	14	0.53	0.80	1.33
RRIM 2020	14	0.36	0.64	1.00
RRIM 2023	14	0.35	0.46	0.81
RRIM 2024	14	0.52	0.74	1.26
RRIM 2025	14	0.63	1.20	1.87
RRIM 2026	14	0.66	0.45	1.11
RRIM 2027	16	0.60	0.70	1.30
RRIM 2028	16	0.42	0.21	0.63
RRIM 2033	15	0.49	0.37	0.86

* Estimated wood volume from Small Scale Clone Trials (SSCT)

Latex Clones

The clones are RRIM 2003, RRIM 2006, RRIM 2010, RRIM 2011, RRIM 2012, RRIM 2013, RRIM 2017, RRIM 2018, RRIM 2021 and RRIM 2022, RRIM 2029, RRIM 2030, RRIM 2031, RRIM 2032.

The five-year mean yields of the RRIM 2000 series latex clones extrapolated from the mean yields in g/t/t from the SSCT ranged from 1901 kg/ha/year for RRIM 2021 to 2548 kg/ha/year for RRIM 2003 (*Table 2.22*). These clones are being tested in LSCT in different environments. However, the three year mean yields of RRIM 2003, RRIM 2006, RRIM 2010, RRIM 2011, RRIM 2012, RRIM 2013, RRIM 2017, RRIM 2018, RRIM 2021 are relatively low ranging from 1040 to 1610 kg/ha/yr (*Table 2.23*). All the clones showed good secondary characteristics and the various disease severity on the clones ranged from moderate to no infection (*Tables 2.24 and 2.25*).

TABLE 2.22 MEAN YIELD (KG/HA/YEAR) OF GROUP 2B RRIM 2000 SERIES LATEX CLONES IN THE SMALL SCALE CLONE TRIALS*

Planting material	Year of tapping					Mean
	1	2	3	4	5	
RRIM 2029	1772	2387	2911	2841	2767	2535
RRIM 2030	1619	1732	2800	2553	2673	2275
RRIM 2031	1901	2345	2568	2698	2617	2425
RRIM 2032	1996	1835	2598	2235	2428	2218

* Extrapolated yield from Small Scale Clone Trials (SSCT)

TABLE 2.23 MEAN YIELD (KG/HA/YEAR) OF GROUP 2B RRIM 2000 SERIES LATEX CLONES IN THE LARGE SCALE CLONE TRIALS

Planting material	Year of tapping						Mean	
	1		2		3			
	g/t/t	kg/ha/yr	g/t/t	kg/ha/yr	g/t/t	kg/ha/yr	g/t/t	kg/ha/yr
RRIM 2003	44.23	1035	57.24	1662	50.50	1732	53.99	1476
RRIM 2010	40.04	624	49.20	1227	44.02	1303	44.42	1051
RRIM 2011	42.91	1402	39.51	1598	39.35	1634	40.59	1544
RRIM 2012	45.61	1184	47.06	1607	57.04	2048	50.02	1613
RRIM 2013	28.38	606	36.55	1226	37.85	1379	34.26	1070
RRIM 2017	33.48	753	36.21	1170	33.01	1189	34.23	1037
RRIM 2018	47.13	902	51.06	1453	51.76	1657	49.98	1337
RRIM 2021	40.06	1286	43.99	1621	40.39	1574	41.48	1493

Tapping system: ½S d/3 6d/7
Average of two trials

TABLE 2.24 SOME IMPORTANT CHARACTERISTICS OF RECOMMENDED GROUP 2B RRIM 2000 SERIES LATEX CLONES

Characteristic	RRIM 2003	RRIM 2010	RRIM 2011	RRIM 2012	RRIM 2013	RRIM 2017	RRIM 2018	RRIM 2021
Yield for first two years	5	5	5	5	5	5	5	5
Resistance to wind damage	4	4	4	4	4	4	4	4
Vigour at opening	5	4	4	4	3	4	4	4
Virgin bark at opening	4	4	4	4	4	4	4	4

5= very good 4 = good 3 = average 2=below average 1=poor NA=not available

TABLE 2.25 DISEASE SEVERITY OF GROUP 2B RRIM 2000 SERIES LATEX CLONES IN SMALL SCALE CLONE TRIALS

Characteristic	RRIM 2003	RRIM 2007	RRIM 2010	RRIM 2011	RRIM 2012	RRIM 2013	RRIM 2017	RRIM 2018	RRIM 2021
Oidium	M	L	L	M	M	L	L	M	L
Colletotrichum	M	M	L	L	M	L	L	M	M
Corynespora	N	L	N	L	L	L	L	N	N

N = Nil VL = Very light L = Light M = Moderate S = Severe NA = Not available

SEEDLINGS

The planting materials from seedlings should only be obtained from recommended seed gardens such as PBIG/GG 6, 7 and 8. Only healthy seedlings with good growth form should be selected for field establishment. The commercial yield of these planting materials is given in *Table 2.26.*

TABLE 2.26. COMMERCIAL YIELD IN KG/HA/YEAR OF RECOMMENDED SEEDLINGS

Planting material	Year of tapping										Mean
	1	2	3	4	5	6	7	8	9	10	
GG 6	620	1010	1330	1490	1520	1510	1620	1640	1580	1690	1401
GG 7&8	1100	1380	1950	1840	1850	1800	-	-	-	-	1653

Data from Golden Hope Plantations Bhd. Tapping system: 3/5S 2d/7

CLONAL SEEDS

Clonal seeds are rubber seeds collected from trees of a particular clone. The clones must be of good progeny and able to produce abundant seeds. They must preferably be high yielding and with good characteristics, such as PB 5/51 and RRIM 623.

Clonal Seed Collection Area

The development of a good crown is important; to encourage flowering and fruiting. This can be achieved by a low planting density. The planting design should preferably be of rectangular or avenue system, with a planting design should preferably be rectangular or avenue system, with a planting distance of 9 m x 3 m. This gives a density of 360 points per hectare. The trees are later gradually thinned out to a final stand of 250 per hectare. The size of a seed garden depends on the quantity of seeds available at each season. It is estimated that between 35,000 and 100,000 seeds can be obtained from a hectare annually. Seed gardens must be isolated to prevent pollen from unknown materials crossing with those in the garden. This can be achieved by having a seed garden situated far away from other rubber areas. Sometimes this is not possible. A seed garden can also be set up within a rubber plantation, provided an isolation belt of 100 m around it is clearly marked out. Clones planted in the isolation belt must be the same as those in the seed garden, but the seeds found in the isolation belt are not collected for use as clonal seeds. The shape of the seed garden should preferably be square, as it gives a bigger isolated inner area than a rectangular-shaped seed garden (*Figure 2.6*).

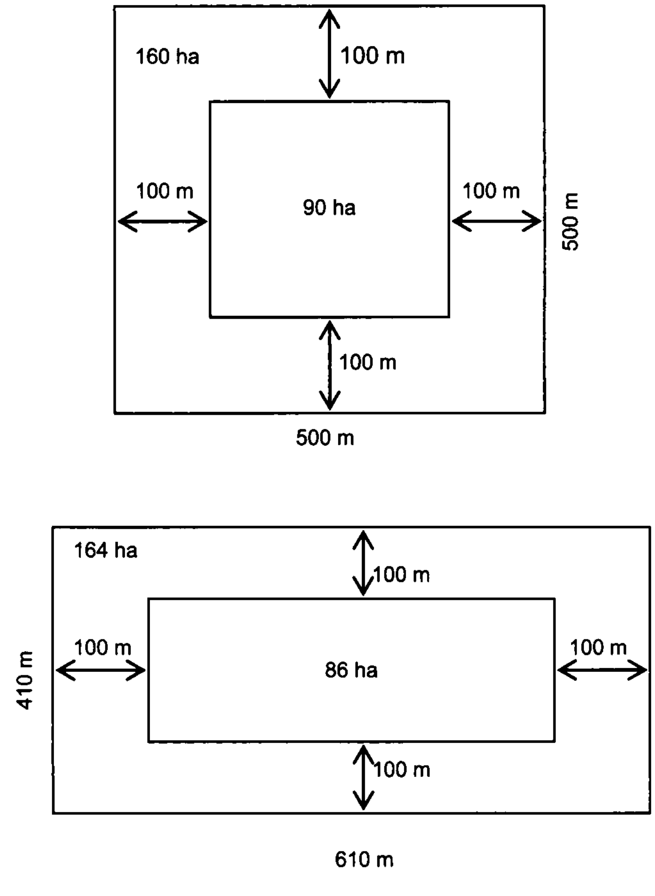


Figure 2.6 Schematic shape of seed gardens – square and rectangular (not to scale)

Arrangement of Clones for the Seed Garden

A clonal seed garden may contain only clone (monoclone) or several clones (polyclone). To encourage cross pollination in a polyclone area, various clones are planted close to one another, and arranged in such a manner that an even cross pollination can take place. Usually, three to five clones are used (*Figures 2.7(i-vi)*).

A A A B B B C C C	Repeat
B B B C C C A A A	Repeat
C C C A A A B B B	Repeat
Repeat	Repeat

i) Three clones A,B,C (each letter = 1 tree)

A B C D	Repeat
C D A B	Repeat
B C D A	Repeat
D A B C	Repeat
Repeat	Repeat

ii) Four clones A,B,C,D ((each letter = 3 or 4 trees)

A B C D E	Repeat
C D E A B	Repeat
E A B C D	Repeat
B C D E A	Repeat
D E A B C	Repeat
Repeat	Repeat

iii) Five clones A,B,C,D,E (each letter = 3 or 4 trees)

A A A A A A A A A A A etc

B B B B B B B B B B B etc

C C C CC C C C C C C etc

Repeat

iv) Three clones A,B,C ((each letter = 1 tree)

A A A A A A A A A A A A etc.

B B B B B B B B B B B B etc.

C C C C C C C C C C C C etc.

D D D D D D D D D D D D etc.

A A A A A A A A A A A A etc.

C C C C C C C C C C C C etc.

D D D D D D D D D D D D etc.

B B B B B B B B B B B B etc.

A A A A A A A A A A A A etc.

C C C C C C C C C C C C etc.

B B B B B B B B B B B B etc.

D D D D D D D D D D D D etc.

Repeat

v) Four clones A,B,C,D (each letter = 1 tree)

A A A A A A A A A A A etc.
B B B B B B B B B B B etc.
C C C C C C C C C C C etc.
D D D D D D D D D D D etc.
E E E E E E E E E E E etc.
B B B B B B B B B B B etc
D D D D D D D D D D D etc.
A A A A A A A A A A A etc.
C C C C C C C C C C C etc.
E E E E E E E E E E E etc.

Repeat

vi) Five clones A,B,C,D,E (each letter = 1 tree)

Figure 2.7 Arrangement of clones in seed garden

If designs as shown in *Figures 2.7(i-iii)* are used, close supervision must be carried out during transplanting, as the clone changes at every point, third point or fourth point. In the designs shown in *Figures 2.7(iv-vi)*, only one clone is transplanted for the planting row. Perhaps this may reduce inter-tree competition for growth since the same type of clone is used along each row and less supervision required during transplanting. But this method is less effective in terms of cross pollination. If close supervision can be guaranteed during transplanting, designs shown in *Figures 2.7(i-iii)* are preferred.

Types of Clonal Seed

For large-scale planting (Class I), PBIG/GG6 seeds are recommended, and for moderate-scale planting (Class II), PBIG/GG7, seeds from approved areas, and seeds collected from boundaries between clones are recommended for large and moderate scale planting. Currently, clonal seeds are obtainable only from commercial sources, such as Sime Darby Berhad.

Besides clonal materials derived from buddings, as described earlier, clonal seeds offer another option of planting material for the plantation industry. However, in Malaysia, this type of planting material is limited to the estates sector only. Smallholders are prohibited from using them.

RUBBER SEED AND ITS GERMINATION

Rubber seed is also a planting material that can develop into a tree. It derives from sexual propagation, that is, through the process of pollination. Seeds are said to be the basis of all rubber trees. Whatever the material that is finally transplanted into the field, it must have started from the seed. Seeds are also raised as stock plants for all grafting processes, such as bud-grafting, cleft-grafting, approach-grafting and root/ seed-grafting.

The Seed

Rubber seed is of the dicotyledon type. The seed coat is semi-hard and has five sides, namely the ventral, dorsal, micropyler, frontal and sides (*Figure 2.8*). A hole known as the micropyle can be found at one end of the seed coat, where the micropyler is. It is through the micropyle, the radical and plumule appear, when the seed germinates. Rubber seed can be considered a vegetable product, because it is edible. It contains oil, which can be extracted for commercial use, and the byproduct can be used for poultry feed mixture.

Figure 2.8 Various sizes of rubber seeds from different clones

Rubber seed comes from the fruit, which is the result of pollination between the male and the female flowers. Rubber trees flower normally in March and August. Seedfall occurs approximately five months later. To ensure germination, fresh-fallen seeds are used, which can easily be recognised from the appearance - shiny, heavy and defect-free. The weight of a fresh-fallen seed differs according to its size, which again differs according to the clone (clonal characteristic). As a guide, a kilogramme of RRIM 623, PB 5/51 and GT 1 seeds consists of 200, 300 and 340 seeds respectively. Rubber seed comes under the group of seeds with high water content and is therefore easily destroyed at very low or very high temperature. It has a short viability period and declines very dramatically, when exposed to direct sunlight (*Table 2.27*).

TABLE 2.27 PERCENTAGE GERMINATION OF RUBBER SEEDS EXPOSED TO SUNLIGHT

Length of exposure to sunlight (day)	Percentage germination
1	95
2	68
3	9
4	1
5	0

Source: Prang Besar Research Station (PBRS)

Therefore, seeds must be collected daily or alternate daily and set for germination immediately. If this is not possible, the seeds must be spread under shade in one layer on the ground, or because of their seasonal nature, they can be packed in 10% damp sawdust or 20% damp powdered charcoal, in small perforated polybags and kept in a cold room at 7-10 °C. In this way, the seeds can be kept for three months.

Stock plants are known to influence the performance of the scion, in terms of growth and later, in yield. Therefore, it is advisable to use seeds from (arranged according to their preference) PB 5/51, RRIM 623, GT 1, RRIM 712, RRIM 605, PB 217 and PB 235 clones for such purpose (*Tables 2.28 and 2.29*).

TABLE 2.28 EFFECT OF SIX ROOTSTOCKS ON GROWTH OF SCION

Type of rootstock	Girth at opening (cm)	Tappability (%)
RRIM 600	49.2	46.2
RRIM 501	49.1	43.4
RRIM 623	51.3	57.3
Tjir 1	50.8	56.6
PB 5/51	53.2	67.8
Unselected seedlings	51.7	63.4

TABLE 2.29 TEN YEARS SCION YIELD

Combination	Yield (kg/ha/year)						Mean rootstock effect
	RRIM 600	48E/ 130	PB 5/51	RRIM 628	SG 170	RRIC 52	
Rootstock							
PB 5/51	2,512	2,469	1,839	1,747	1,716	983	1878
RRIM 623	2,119	2,094	1,870	1,637	1,604	807	1,688
Unselected Seedlings	2,155	2,101	1,640	1,503	1,503	785	1,617
Tjir 1	2,317	2,004	1,566	1,630	1,292	859	1,611
RRIM 501	1,953	2,024	1,480	1,528	1,582	814	1,563
RRIM 600	2,097	1,600	1,387	1,414	1,366	892	1,459
Mean scion effect	2,192	2,049	1,630	1,577	1,513	857	1,636

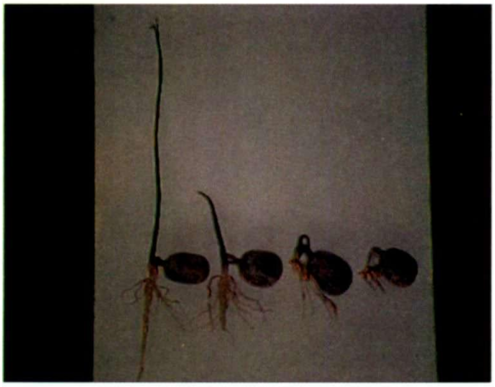
Seed Germination

Seeds that are to be planted out should first go through the germination process. For large quantity of seeds, it is economical to use the germination bed. This can be done by constructing a raised bed of loose soil, river sand or well-weathered sawdust 15 cm high, 100 cm wide and the length depending on the number of seeds to be set; each square metre of germination bed surface can accommodate approximately 1,000 seeds. A raised partial shade of 1 m high should be erected over the bed to prevent direct sunlight. The seeds are spread over the bed in one layer, close together. They are then pressed into the germination bed surface. The seeds are covered by putting a layer of loose soil, river sand or well-weathered sawdust to the thickness of about 1.5 cm. The seeds are watered twice daily. Germination occurs on the tenth day, but peak germination is between two and three weeks.

The best time to transplant germinated seeds is when the radicals appear and the plumules are just visible above the bed surface. If transplanting is delayed, the radicals and plumules grow too long and much damage can occur. This should be avoided by timing the nursery operation well. The germinated seeds are carefully levered out of the bed with the help of a small piece of flat-end wood or bamboo. As the cotyledons provide early food to the sprouting plumules/radicals, care should be taken not to detach the seeds from them. The germinated seeds must be transplanted immediately (*Figure 2.9*)

a) Fresh-fallen rubber seeds

(b) Setting seeds on sawdust-mounted germination bed



(c) Various stages of germination of rubber seed

(d) Germinating seeds

Figure 2.9 Germinating rubber seeds

NURSERIES AND THE PRODUCTION OF PLANTING MATERIALS

A nursery is a special area, where planting materials are raised for transplanting into the field. A rubber nursery can be considered as a factory producing planting materials.

Objectives of Setting Up a Nursery

The objectives of establishing a rubber nursery are to:

- nurture and raise high quality planting materials in large scale
- prepare advance-aged planting materials, if necessary

- ensure that planting materials transplanted into the field achieve high initial establishment success
- reduce costs of plantation development by reducing failures at the initial stage
- obtain plants in the field reaching early maturity

Choice of Nursery Site

Rubber nursery is divided into two categories – ground nursery and polybag nursery. In a ground nursery, the plants are planted on the ground, whereas in a polybag nursery, the plants are planted in the polybags arranged in rows in a nursery. In selecting a nursery site, the following factors must be considered.

- The soil must be well structured and textured (for ground nursery only)
- There must be a good source of water supply
- The land must be flat or slightly sloping
- Water table should be below 75 cm from the surface (for ground nursery only)
- The land should be an open area (not under shade)
- It must be free from root disease source
- Preferably having good infrastructure

Type of Nursery

There are no less than eleven types of nursery producing various types of planting materials. The commonly practised ones are:

- Budstick multiplication nursery (ground nursery)
- Budded stump nursery (ground nursery)
- Budded stump in polybag nursery
- Young budding nursery
- High budding nursery
- Core stump nursery (ground nursery)

Establishment of Nursery

A nursery site must be cleared and cleaned of all vegetations. This includes removal of tree stumps and roots. For a ground nursery, the land must be ploughed twice, followed by harrowing and rotovation or harrowing once. Basal fertiliser of 250 kg/ha ground magnesium limestone is broadcast just before the second ploughing and 625 kg/ha of rock phosphate, such as *Christmas Island Rock Phosphate (CIRP)* just before rotovation. For a polybag nursery, tilling of land is unnecessary. Instead, filled polybags are laid in straight double rows as soon as the site is lined and cleared *(Figure 2.10)*. For large nurseries, watering system such as the sprinkler or the *Sumi Sansui* be installed. Planting distances for the various nurseries described above are shown in *Table 2.30*.

(a) Transplanting germinated seeds into polybag

(b) Growing seedlings in polybag

(c) Maintenance of seedlings in polybag

(d) Polybag nursery

Figure 2.10 Establishment of polybag nursery

TABLE 2.30 SUGGESTED PLANTING DISTANCES IN RUBBER NURSERIES

Type of nursery	Planting distance (cm)	Approximate density per hectare
Budstick multiplication	120 x 120	6,944
Budded stumps	60 x 15	111,111
Budded stump in polybag	96 x 18*	115,740
Young budding	96 x 18*	115,740
High budding	180 x 25*	44,444
Core stump	180 x 70	7,936

*Double rows

Budstick multiplication nursery. In a budstick multiplication nursery, planting holes of 45 cm x 45 cm x 45 cm size are dug at each marked out planting point. Polybag buddings (budded stumps in polybags or young buddings in polybags) are used as starting materials. Although other materials can be used, budded stumps in polybags and young buddings are able to produce budsticks at a faster rate. Polybag buddings are then transplanted into the prepared planting holes.

Budded stump nursery. A budded stump nursery, which is also a ground nursery has planting rows marked at intervals of 60 cm, along two opposite boundaries *(Figure 2.11)*. Lining ropes marked with a planting distance of 15 cm are stretched along planting rows already marked. A rounded sharp-pointed stick is used to punch a cavity of 8 cm deep (depth may vary according to the length of the radical of the germinated seed to be transplanted) in the soil at every point marked along the lining rope. Germinated seeds are then placed in the carvities with the radicals downward. The cavities are refilled by gently pressing the soil around the seeds. Seeds with twisted radicals should not be transplanted. The seeds must not be detached from the radicals during the transplanting operation.

Figure 2.11 Ground nursery

Budded stumps in polybags nursery. Polybags of 18 cm x 38 cm layflat dimensions are filled with suitable soil, which has been mixed with rock phosphate at 56 g per bag of soil. Planting rows are marked at intervals of 96 cm along two opposite boundaries of the nursery. A 40-cm strip of the soil along each planting row is roughly levelled to facilitate proper placement of the polybags. At each planting row (where the levelled strip is) two rows of filled polybags are placed. The polybags can be kept upright by slightly mounting the soil at the base or by stretching galvanised wires or by fixing wooden beroties along the sides. To facilitate transplanting, the soil in the polybags is first watered. A round sharp-end hardwood stick, the size of which should be slightly larger than the tap root of the budded stump to be transplanted, is used. The tap roots are planted with their tips 5 cm above the base of the polybags. Budded stumps with longer roots are pruned off to fit into the polybags. Budded stumps with twisted or very short tap roots are discarded. After measuring the tap root of the budded stump with the above stick, it is pierced into the soil to the required depth. The tap root of the budded stump and is then placed into the cavity. Water is again poured into the bag to close up the cavity and to prevent air pocket around the tap root (*Figure 2.12*).

(a) Extracting budded stump

(b) Selection of budded stump

(c) Prunning of tap root

(d) Placing tap root in polybag

(e) Arranging polybags in two rows

(f) Budded stump with new shoot

Figure 2.12 Transplanting budded stumps into polybags

Young budding nursery. Preparation and laying of polybags in a young budding nursery are the same as for the budded stumps in polybags nursery. But in this type of nursery, germinated seeds are transplanted into the polybags, to be raised as seedling stocks for subsequent budding. Using a flat sharp-end piece of wood or bamboo, a cavity is made in the soil in the polybag, large and deep enough to fit in the radical and the seed. The germinated seed is placed in the cavity with the radical downward. The cavity is refilled with soil and carefully pressed. The seed must be fully covered with soil.

High budding nursery. Preparation and laying of the polybags for a high budding nursery are the same as described earlier, except that polybags are bigger, with layflat dimensions of 25 cm x 50 cm and the inter-row distance is 180 centimetres. Germinated high quality clonal seeds such as PBIG/GG6 or PBIG/GG7 are transplanted into the polybags. The technique of transplanting is the same as described earlier. They are raised as stock plants for subsequent budding.

Core stump nursery. In the preparation of a core stump nursery, a trench of 30 cm wide and 45 cm deep is dug along each planting row. Polybag young buddings are placed in the trench at 45 cm apart. The trench is refilled with soil, incorporating 56 g of rock phosphate per point (*Figure 2.13*).

(a) Preparing trenches for polybag buddings

(b) Transplanting polybag buddings into prepared trenches

Figure 2.13 Preparing core stump nursery

Maintenance of Nursery

Watering of the plants is essential, especially for the polybag nurseries. Using the sprinkler or *Sumi Sansui* system, water is released twice daily for a total of two hours. Weeds are regularly controlled, initially by manual weeding. Herbicides are only used when the plants are at least two months old, and when the leaves have hardened. Spraying of *Paracol* at 2 litres in 450 litres of water per hectare should give satisfactory control of nursery weeds. Thinning out runts, genetic yellows, defective and chronically diseased plants are carried out from time to time. Manuring is done following specific schedules according to the type of nursery.

Budstick multiplication nursery. Fertiliser is applied according to schedule shown in *Table 2.31*. The scion shoot is allowed to grow until 60-90 cm of brown bark has been formed. The scion stem is then cut-back at a height of 60 or 90 cm, just above a whorl of buds. Several side shoots will emerge, but only four or five vigorous ones are retained to form branches. Budsticks can be obtained by pruning back; as the snags left behind will again regenerate more shoots. Budsticks with green to dark green bark are normally used. After repeated pruning, the plant gives a bush-like crown formation. This is why this nursery is sometimes known as the bush nursery. Each budstick multiplication nursery should be productive for at least ten years.

TABLE 2.31 MANURING SCHEDULE FOR BUDSTICK MULTIPLICATION NURSERY

Time of (month after planting)	Types of fertiliser	Dosage (g per plant)
2	Equivalent Mixture Magnesium X	42
3	Equivalent Mixture Magnesium X	42
4	Equivalent Mixture Magnesium X	42
5	Equivalent Mixture Magnesium X	42
7	Equivalent Mixture Magnesium X	42
9	Equivalent Mixture Magnesium X	42
11	Equivalent Mixture Magnesium X	42
13	Equivalent Mixture Magnesium X	42
15	Equivalent Mixture Magnesium X	42

After fifteen months and onwards, fertiliser application is continued after each harvesting of budsticks.

As soon as the budsticks are harvested, the leaf petioles are removed by pruning to avoid loss of water in the wood. Both the scale and the axillary buds on the budstick are usable. To facilitate packing, budsticks are cut to 30 cm length and usually contain an average of two buds per stick. If the budsticks are to be kept overnight and longer, 1 cm at both ends must be sealed in molten wax to slow down the drying process. Budsticks are packed in cardboard or plywood boxes, interlayered by 10% damp sawdust. They should be kept in a cool place, but not exceeding a week. Where possible, budsticks must be used fresh (*Figure 2.14*).

(a) Scion stem ready for cutback

(b) Advanced stage of green budstick nursery

(c) Trimmed budsticks

(d) Dipping budstick ends in molten wax

(e) Packing budsticks in cardboard box

(f) Packed budsticks ready for transportation

Figure 2.14 Producing green budsticks

Budded stump nursery. Fertiliser is applied according to schedule (*Table 2.32*). The seedling stocks are green-budded at five to six months old. After three weeks, the successful budded plants are extracted. The stem of each plant is cut-back at 5 cm from the bud eye, and the cut end sealed in molten wax. The tap root is pruned off to 30-45 cm, while the side roots are all pruned off flush. The tap root is then dipped in IBA root stimulant formulation. If the budded stumps are to be transported to a long distance, they should be packed in 10% damped sawdust, at fifty stumps per bundle (*Figure 2.15*).

TABLE 2.32 MANURING SCHEDULE FOR BUDDED STUMP NURSERY

Time of application (month after planting)	Types of fertiliser	Dosage (g per plant)
2	Equivalent Mixture Magnesium X	60
3	Equivalent Mixture Magnesium X	60
4	Equivalent Mixture Magnesium X	60
5	Equivalent Mixture Magnesium X	60

Budded stumps in polybags nursery. Fertiliser in applied according to schedule (*Table 2.33)*. The scion shoot is allowed to grow until two whorls of hardened leaves have been formed. The material is then ready for transplanting (*Figure 2.16*).

TABLE 2.33 MANURING SCHEDULE FOR BUDDED STUMP IN POLYBAGS NURSERY

Time of application (month after planting)	Types of fertiliser	Dosage (g per plant)
1	Equivalent Mixture Magnesium X	28
3	Equivalent Mixture Magnesium X	28

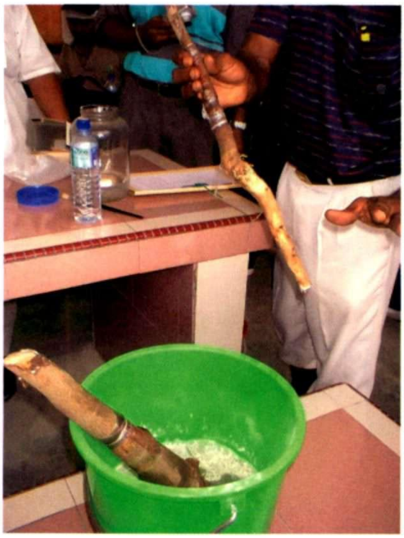
Young budding nursery. Fertiliser is given according to schedule (*Table 2.34*). The seedling stocks are young-budded at ten to twelve weeks old. The stocks of successful buddings are cut-back. The scion shoots are allowed to grow until two whorls or hardened leaves have been formed. By this time, the tap roots may have penetrated the ground, and may require tailing. Two weeks before transplanting, the polybags are slightly lifted to severe the roots ground level. Watering must be continued until the materials are taken out of the nursery (*Figure 2.17*).

(a) Seedling nursery

(b) Trimming tap and side roots

(c) Trimmed budded stumps

(d) Waxing tap root



(e) Dipping tap root in IBA formulation

(f) Packing with damp sawdust ready for transportation

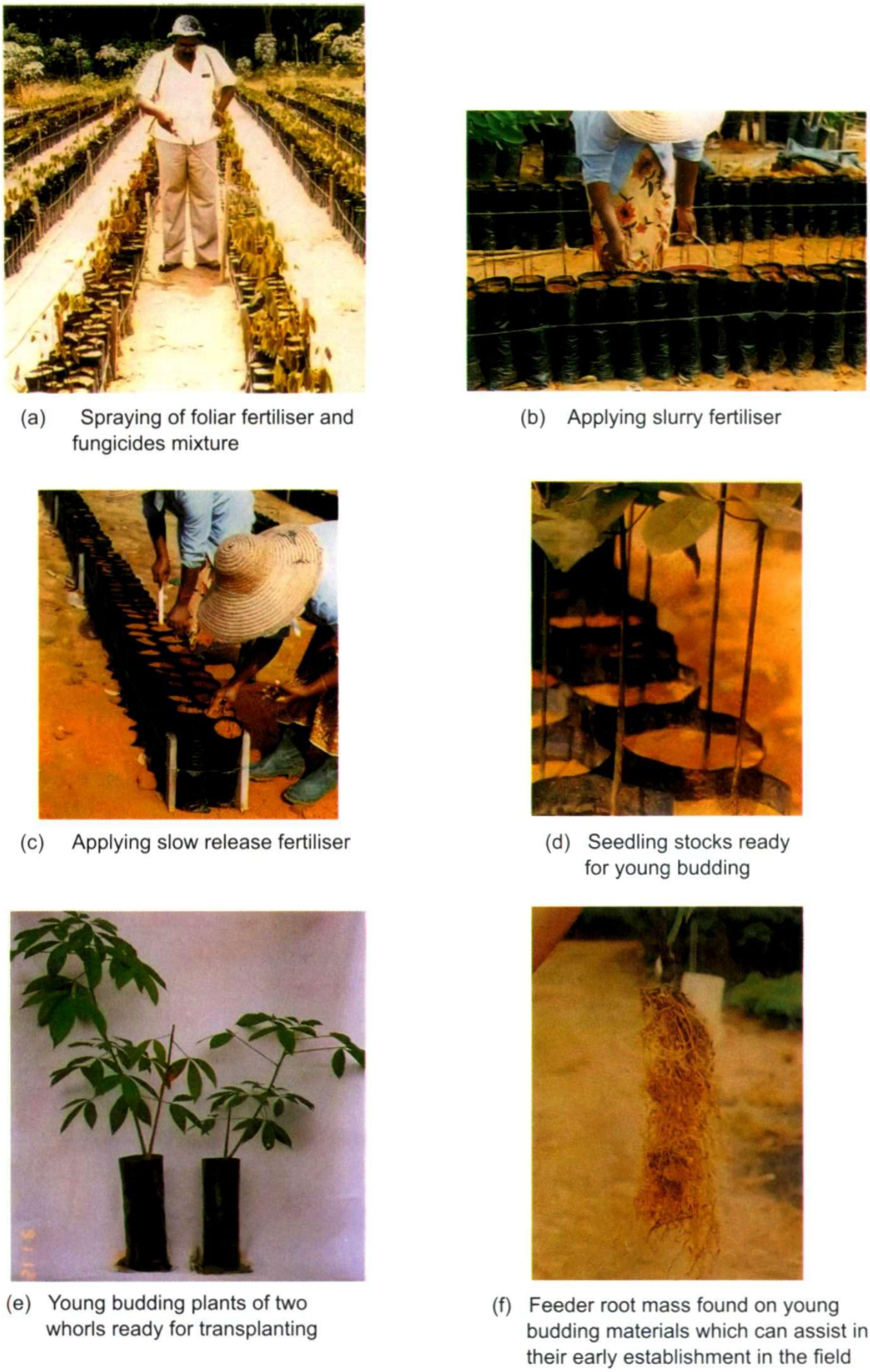
Figure 2.15 Production of budded stumps

Figure 2.16 Polybags budded stump nursery where the scion shoots have emerged to two hardened whorls of leaves and ready for transplanting

TABLE 2.34 MANURING SCHEDULE FOR YOUNG BUDDING NURSERY

Time of application	Type and dosage of fertiliser
After transplanting germinated seeds in polybags 1-8 weeks (twice weekly)	Spraying of foliar feed and fungicides mixture of *Bayfolan* = 15 ml + *Dithane M-45* = 10 g + *Daconil* = 12 g + Water = 4.5 litres
2-6 weeks (weekly)	NPKMg @ 15:15:6.4 with soluble phosphate 56 g + 4.5 litres water = 40 – 60 ml per polybag
Stock plants at one whorl Stage After cut-back of stock Plant 2 weeks and onwards (twice weekly)	Or* Slow release fertiliser such as *Nurseryace* or *Kokei* = 7 g per polybag Spraying of foliar feed and fungicides mixture of *Bayfolan* = 15 ml + *Dithane M-45* = 10 g + *Daconil* = 12 g + Water = 4.5 litres
4 weeks and onwards (weekly) Scion reaches copper-bronze leaflet stage	NPKMg @ 15:15:6.4 with soluble phosphate 56 g + 4.5 litres water = 40-60 ml per polybag Or* Slow release fertiliser such as *Nurseryace* or *Kokei* = 7 g per polybag

*When there is shortage of labour



(a) Spraying of foliar fertiliser and fungicides mixture

(b) Applying slurry fertiliser

(c) Applying slow release fertiliser

(d) Seedling stocks ready for young budding

(e) Young budding plants of two whorls ready for transplanting

(f) Feeder root mass found on young budding materials which can assist in their early establishment in the field

Figure 2.17 Manuring young budding materials

High budding nursery. At the moment, the fertiliser schedule recommended for young budding nursery is also used for the high budding nursery. The stock plants are green-budded at five to six months old. Budding is done at a height of 100 centimetres. Four weeks after budding, the top portion of successful budded plants are cut-back and the scions are allowed to grow to one or two hardened whorls of leaves for transplanting. Prior to that, tailing is also done as described earlier. Again, watering must be continued until the materials are taken out of the nursery.

High budding materials have two productive stem components. Upon maturity, the stems or trunks will have 100 cm of good clonal seedling materials at the lower part, and 200 cm of budded materials above them. This allows for early tapping, as, by nature the seedling tree tapers upwards and the bottom portion reaches maturity earlier (*Figure 2.18*).

Core stump nursery. Fertiliser is applied according to schedule *(Table 2.35)*. As the scion shoots grow, side branches may also appear, which must be pruned off. This is to obtain clean stems of 210-240 cm for exploitation later on. Diseases and pests are also controlled when necessary. The plants can be transplanted at 12-18 months old. The stems are cut-back at a height of 240 cm, just above a whorl of buds. The cut ends are treated with suitable wound dressing. The stems are then painted white using dehydrated lime (1 kg + 1 litre water) to prevent scorching of the bark. At the same time, the tap roots are pruned off (tailing) to 45-60 cm, with a root pruner (oil palm fruit harvesting chisel). The plants, now called core stumps (maxi stumped buddings with soil cores), can be extracted for field transplanting, when the topmost buds have broken (bud-break stage). This takes approximately 10-14 days after cut-back. The stumps can also be left in the nursery much longer until all the leaves at the top whorl have hardened, thus, giving flexibility to the time of transplanting such materials. Care must be taken to prevent the soil core surrounding the roots from breaking up. These are categorised as advance-aged planting materials, in view their large stem size. They are expected to be brought into tapping much earlier (*Figure 2.19*).

TABLE 2.35 MANURING SCHEDULE FOR CORE STUMP NURSERY

Time of application	Type of fertiliser	Dosage per plant
Immediately after planting	*Nurseryace**	14 g (2 pellets)
Every six months	*Nurseryace**	14 g (2 pellets)

**Kokei* can also used, but every three months. The fertiliser is slightly buried in the soil, very close to the plant.

(a) Successfully high budding

(b) High budding at one whorl stage

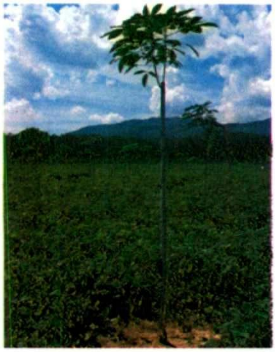
(c) High budding materials transplanted out

Figure 2.18 Production of high budding materials

(a) Cutting-back scion stem to height of 240 cm and apply wound dressing to the cut end

(b) Manual extraction of white-washed core stumps

(c) Extracting core stumps with the help of an excavator at bud-break stage



(d) Core stumps at one whorl stage after planting

(e) Core stumps material planted in the field

Figure 2.19 Production of core stumps

ROOT INDUCTION

Growth of rubber tree depends mainly on its roots, especially the side ones, which bear the feeding roots. When preparing budded stumps for transplanting, all the side roots are normally pruned off flush with the tap roots to facilitate planting. Therefore, early and fast re-emergence of the side roots in abundant quantity after planting is most important, to assist in the sprouting of the scions, and subsequently in the growth of the plants (*Table 2.36*). With good root system, the plants are able to uptake water and nutrient solution efficiently. This indirectly influences the overall growth of the tree. By using plant growth regulators, such as *IBA (Indolebutyric acid)*, the above objectives can be achieved (*Figure 2.20*).

TABLE 2.36. EFFECT OF IBA 2000 ROOT PRODUCTION OF BUDDED STUMPS OF DIFFERENT GIRTH SIZES

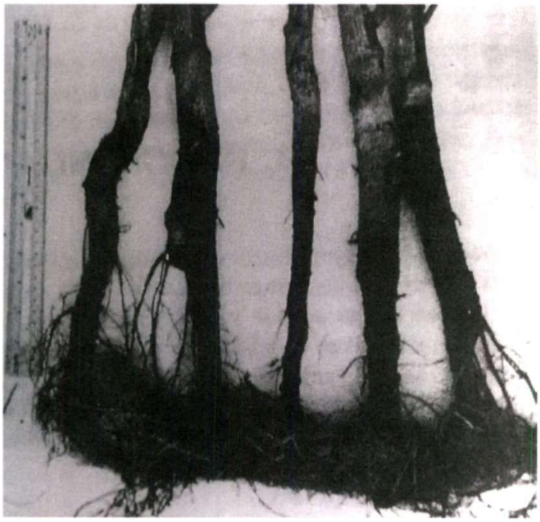
Girth diameter (cm)	Treatment	Mean dry weight of roots (g)		
		2 weeks	4 weeks	8 weeks
1.25	Control	0.23(100)	0.27(100)	0.48(100)
	IBA (2000 ppm)	0.53(230)	0.75(278)	1.42(296)
2.50	Control	0.27(100)	0.36(100)	0.42(100)
	IBA (2000 ppm)	0.30(111)	0.72(200)	1.57(374)
3.75	Control	0.00(100)	0.29(100)	0.47(100)
	IBA (2000 ppm)	0.13(130)	0.74(255)	1.36(289)
5.00	Control	-	0.31(100)	0.55(100)
	IBA (2000 ppm)	-	0.83(268)	1.64(298)

The clone budded was RRIM 600
Figures within brackets indicate percentage response of control

IBA Formulation

To prepare the formulation, dilute 2 g of *IBA* (product of Sigma Chemicals, USA) in 10 ml of absolute alcohol. Mix 1 kg of kaolin powder with 250 ml of water and 750 ml of 50% (commercial) alcohol, separately. Then mix all the ingredients thoroughly in a blender; and dry the mixture in an oven overnight at 70 °C until it turns to powder. The powder can be kept for a long period, provided it is not exposed to light. In this formulation, the quantity of *IBA* in kaolin is 2,000 parts per million (ppm).

(a) Without *IBA 2000* treatment



(b) With *IBA 2000* treatment

Figure 2.20 Effect of IBA on root development of budded stumps

Application Method

The *IBA* formulation must be diluted before use. To dilute it, dissolve 1 kg of the powder in 1,050 ml of water and 750 ml of 50% alcohol to obtain a solution of 1:1.8 powder/ solution. Pour the mixture into a special cylinder. Dip the tap root of the budded stump into the cylinder containing the mixture, and allow it to dry under shade before transplanting or packing. The remainder of the diluted mixture, if any, can be kept for use later, but not exceeding three months.

The oldest rubber tree growing in Kuala Kangsar, Perak. This specimen came from the original batch of seedlings from Brazil.

CHAPTER 3

SOILS AND LAND PREPARATION

Soil is the uppermost layer of the earth crust, which is formed by partial or complete disintegration or decomposition of parent materials, subject to various degrees of weathering. The composition of soil is 45% mineral particles, 25% soil air, 25% water and 5% organic material. Although there are plants that can survive without soil, the majority of them, including rubber, need soil as a medium for growth.

Factors Influencing Soil Formation

The formation of soil depends on factors such as parent materials, vegetation, climate, topography and time. This means that the principle of soil formation is the action of climate on parent materials and vegetation, modified by topography, over a period of time.

The interaction of similar weathering process with different parent materials produces different kinds of soil. It is also true that the development of the same parent materials under different climatic regimes and vegetation can also result in the formation of different soils. Topography determines the ease of rain water penetration into the ground and the drainage of water from specific areas. Topography has therefore a modifying influence on the degree of weathering and the soil that is formed.

As the climate and vegetation do not vary very much between north and south of the Peninsular, Sabah and Sarawak, the type of soils formed in Malaysia depends mainly on the parent materials and topography.

Parent Materials

Parent materials are the main factor in soil formation. In fact, they are the basis of soil type. They are mostly made up of various types of rocks, as listed below.

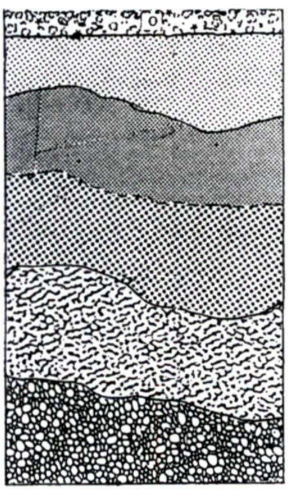
- Intrusive rock - granite, granodiorite, gabbro and serpentinite
- Extrusive rock - rhyolite or dacite, andesite and basalt
- Sedimentary rock - conglomerate
- Hybrid rock - carbonaceous shale
- Chemical origin rock - limestone and quartzite
- Metamorphic rock - slate, phyllite and schist

Weathering and Soil Formation

Soils are formed from mixtures of fragmented and partially or fully weathered rocks, mineral and organic matter in varying proportions and are dynamic in character. They reach an equilibrium stage with the environment after a long period of exposure to a given state of conditions. The fragmentation of rocks and parent materials is the result of climatic forces. Weathering is either chemical or physical. In physical weathering, the parent material is broken down by environmental conditions, such as temperature, running water, and action of plant roots. Chemical weathering causes disintegration or changes of substances present in the parent material, often the result of biological and chemical activities.

Soil Profile

The degree of interaction of physical and chemical processes influences soil genesis in two steps - accumulation of materials and differentiation of horizons in a profile. In creating a particular profile, oxidation may cause discolouration of fragments of the parent rock to a considerable depth. Clay minerals and iron compounds leached from the upper part of the profile may be concentrated lower down the profile. Such distinctive successive layers approximately parallel to the ground surface and produced by soil-forming processes are called horizons, which characterise the soil. By colour, chemical tests, grain-size analysis and other criteria, soil profiles can be sub-divided into many horizons and sub-horizons, and by comparison of their nature and intensity, the soil can be classified. Thus, a typical profile usually consists of five main horizons, from the surface down to the unaltered rock (*Figure 3.1*).



- O Fresh or partially decomposed organic matter

- A Abundant roots and accumulation of humus in a primarily mineral horizon, clay, carbonates and iron leached to deeper horizons

- B Finely divided humus and clay accumulated from the A horizon

- B Accumulated clay, iron oxide and some humus, prismatic or blocky structure

- C Slightly altered parent material

- R Unaltered rock material

Figure 3.1 A typical soil profile

Process of Soil Formation

Not all the five main horizons are seen in a single soil profile. Depending on the degree of development, three or sometimes only two horizons are present. The differentiation of horizons is determined by the combination and balance of the physical processes, which in turn, governed by the relative strength of the five main soil formation factors. The relative importance of each process is reflected in the final character of the soil.

As the basic physical and chemical processes are much controlled by the main soil formation factors, especially that of climate on a regional basis, different sets of combinations of these processes are specific to different geographical and climatic zones. The more important soil-forming processes influencing the development of soils in Peninsular Malaysia are described below.

Latosolisation. This is the most common process. Under abundant rainfall and high temperatures of the tropics, there are great weathering forces. Hydrolysis and oxidation are rapid and the soluble bases of calcium, potassium, magnesium and sodium are leached away quickly. Due to the mobility of these cations, the pH is lowered and this low acidity condition is worsened by the rapid decay of the organic residues and the immediate release of the bases in organic combination. As a result, the solubility of silica is enhanced, retarding those of iron, manganese and aluminium. With good drainage, intense oxidation takes place. As weathering proceeds, the resultant profiles are high in sesquioxides and low in silica. The residual and accumulated iron produce very deep bright red coloured soil such as the Kuantan, Segamat, Prang and Langkawi series.

Laterisation. As weathering processes occur further on the latosol, replacement action of silica by hydroxyl groups takes place and hydrated iron and aluminium oxides are formed. These oxides called goethite and bauxites are concretionary in nature and they constitute laterites or ironstones, which range 1-50 cm in size. These are commonly found in many rubber-growing soils of Peninsular Malaysia. Sometimes, such laterites, when cemented, form thick, hard and impenetrable ironstone pans, which are common in Melaka, Gajah Mati, Tavy and Changloon series.

Ground water laterisation. At times, ground water laterites can be formed on low terrain areas due to fluctuating ground water table. This influences a rapid alternating oxidation-reduction action on the lower lying materials such as the parent material, resulting in the formation of ground water laterites. This is a notable feature in some of the riverine alluvial soils and soils derived from sedimentary materials such as the Batu Anam series.

Podzolisation. This is only confined to soils, such as the Rudua and Rusilia series. With high organic cycle, low terrain, which does not drain water quickly, and sandy medium, which eases leaching, there is considerable removal of salts and carbonates. This is followed by marked release and transfer and redeposition of organic humic acids and sesquioxides, especially iron, down the lower lying layers, leaving a whitish bleached A2 horizon in the upper 30 cm layer and dark, slightly reddish-brown layer of redeposited mixed organic acids and iron oxides in the lower layers.

Podzolic process. In the higher terrain areas and under abundant rainfall, podzolisation process is modified and gives way podzolic influences. Under better drained conditions and a more intense weathering process, easily weathered minerals are changed to secondary clay, oxides and iron. The bases are lost by leaching segregation of insoluble oxides as amorphous materials occur. Clays are formed in its place and vertically moved at depths so that a textural B horizon, with bright or yellowish-red colour, occurs. Soils with such diagnostic horizons with clay formation, movement and accumulation at depths are featured in Rengam, Jerangau, Bungor and Munchong series. The textural B horizon is usually thick and as such, these soils are very deep, extending up to 150 cm and more.

Gleization. This process is influenced by a high permanent water table on low terrain. There is an excess of soil moisture due to poor drainage, which is either due to the soil characteristics or because the soil is situated in low-lying area. As a result, there are little alteration processes, and undecomposed organic layer lies on the surface, with a lower layer retaining its grey colour due to little alteration in deposited materials. This is a feature in Kangkong and Selangor series soils. But, going inwards from the coast, where the terrain is higher, fluctuating water table causes alternating dry and wet conditions. Oxidation of iron-rich spots takes place, resulting in red, yellow or brown streaks of iron mottles in the profiles of Briah and Sitiawan series.

Soil Colour

Colour of the soil must be determined when the soil is moist. The colour may be uniform or may vary, the most common being bright, dark or mottled, depending on drainage. Colour is also determined by the type of minerals present in the soil. For example, red shows that there is goethite or hermatite and and black shows there is manganese oxide, montmorilonite or organic materials.

Soil Texture

Soil texture is a measure of the relative proportions of the various types of soil particles in the solid phase of the soil. The particles are graded by their diameter size and a name is given for each type. *Table 3.1* gives the international particle names and specifications of soil texture.

TABLE 3.1 SOIL FRACTIONS AND THEIR DIAMETER SIZE LIMITS

Fraction name	Diameter size limit (mm)
Gravel	> 20
Coarse sand	2.0-0.2
Fine sand	0.20-0.02
Silt	0.02-0.002
Clay	<0.002

The texture of soil determines whether the soil can retain water and nutrients. It is therefore, considered important in terms of soil fertility. Soil texture can be roughly estimated by feeling with the fingers. Too much clay or too much sand in the soil is undesirable for plant growth, including rubber. Therefore, a right combination of the two is needed. Texture depends very much on the parent material. For example, basalt produces clay soils, while granite produces sandy clay soils. The higher the degree of weathering, the more clayey is the resulting soils. The textural names of soils are as listed below, while the textural classes are as shown in *Figure* 3.2.

- Clay
- Clayey loam
- Sand
- Sandy clay
- Sandy clay loam
- Sandy loam
- Loam
- Loamy sand
- Silt
- Silty clay
- Silty loam
- Silty clay loam

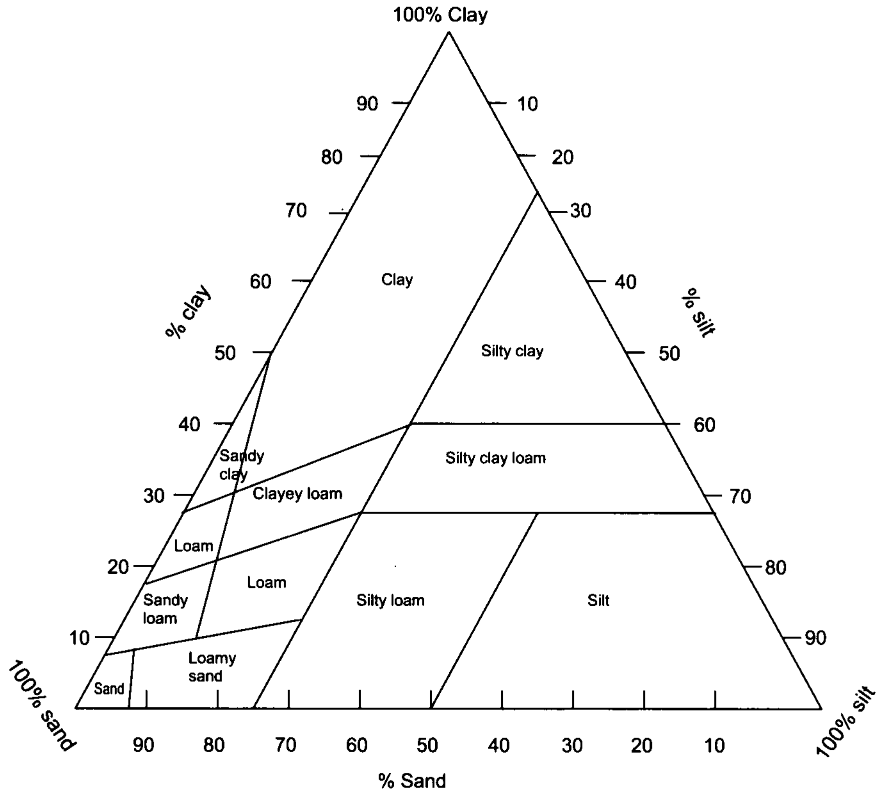


Figure 3.2 Soil textural classes guide

Soil Structure

Soil structure refers to soil particle aggregates based on the aggregate that can be easily broken under very slight pressure. For example, sandy soil is very friable in nature, and connot be formed into any structure, thus it is said to be structureless. Unlike clay soil which cannot be easily broken up. Clay soil is considered to be of very poor structure, as it is too blocky. Structure influences the supply of water, air and nutrients for plant growth. Ideally, there should be an assortment of fine and coarse aggregates arranged in a pattern that will allow adequate water storage and aeration. The aggregates must be stable enough so that the structure can be preserved for a long time. *Figure 3.3* displays some common soil structures in Peninsular Malaysia soils.

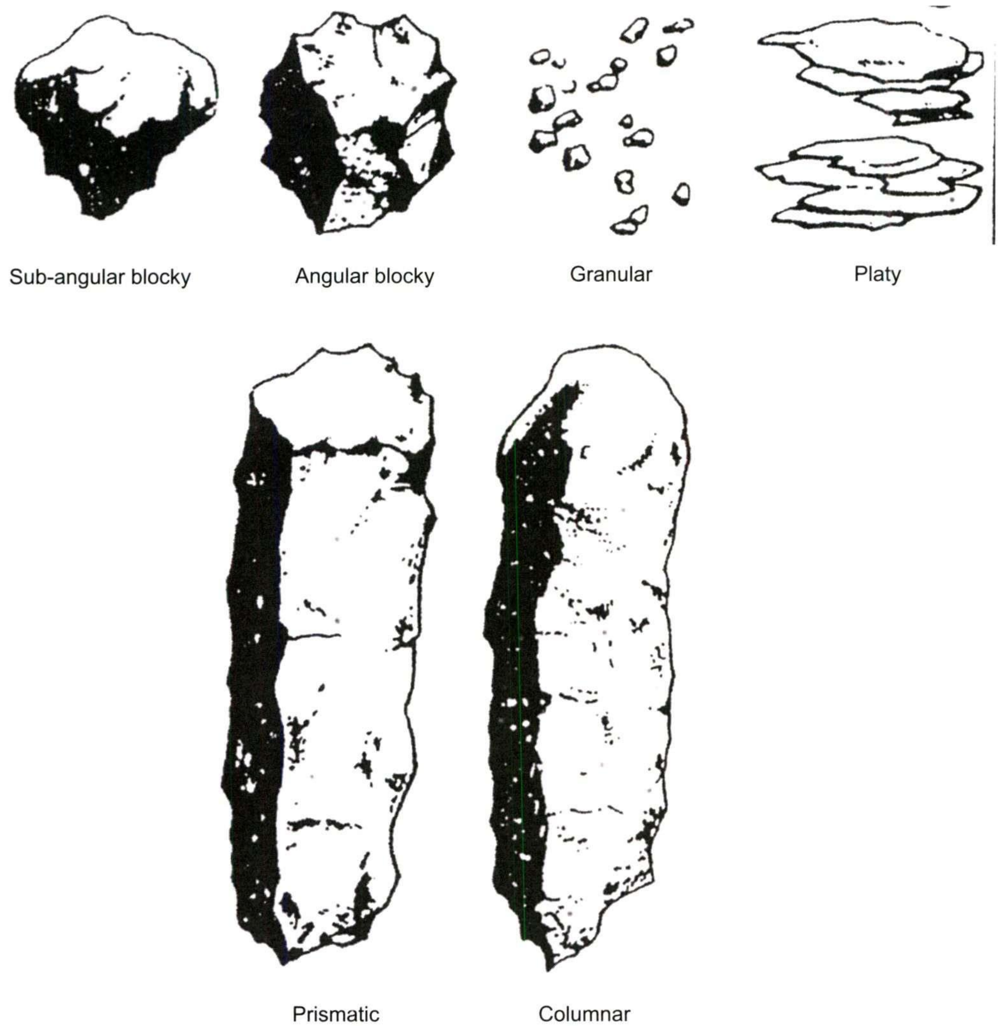


Figure 3.3 Various types of soil pebbler

Soil Series

It is important to classify soils in order to efficiently exploit them. Classification of soils also helps to determine their suitability and the type or amount of agro-management input to be given. In rubber cultivation, soil management is important to maximise yield of a clone in a particular area, and this depends partly on the soil series. A soil series can be defined as a group of soils, similar in profile properties, formed from parent material of the same geological origin. *Table 3.2* describes a number of soil series found in rubber-growing areas of Peninsular Malaysia.

TABLE 3.2 SOME SOIL SERIES IN RUBBER-GROWING AREAS OF PENINSULAR MALAYSIA

Series	Parent material	Colour	Texture	Structure	Consistency
Batu Anam	Shale	Pale yellow to light grey	Clay to silty clay	Strong, medium to coarse angular blocky to prismatic	Firm and very firm
Durian	Shale	Strong brown to yellowish red	Silty clay to clay	Moderate, medium angular blocky to prismatic	Firm and very firm
Gajah Mati	Shale	Strong brown	Clay loam	Moderate, medium and fine sub-angular blocky	Very friable
Jeram	Shale	Strong brown to yellowish red	Sandy clay loam to clay	Strong coarse granular and fine sub-angular blocky	Friable to firm
Kuala Brang	Shale	Dark greyish brown to light olive grey	Fine sandy loam to clay loam	Strong medium granular to weak very coarse sub-angular blocky	Friable to firm
Melaka	Shale	Brownish yellow or redder	Clay loam to fine sandy clay	Strong, fine and medium sub-angular blocky	Very friable
Munchong	Shale	Yellowish brown to strong brown	Silty clay loam to silty clay	Moderate to strong fine and medium sub-angular blocky	Friable to firm with depth
Pohoi	Shale	Pale brown to variegated yellow	Clay loam to clay	Moderate, medium and coarse crumbs and granular to strong, coarse prismatic	Friable to very firm
Prang	Shale	Yellowish red	Heavy clay	Moderate to strong, fine and medium sub-angular blocky	Very friable
Rengam	Granite	Brownish yellow to yellowish brown	Coarse sandy clay loam to coarse sandy clay	Weak to moderate, medium sub-angular blocky	Friable
Jerangau	Granodiorite	Strong brown to yellowish red	Fine sandy clay loam to fine sandy clay	Moderate to strong, fine and medium sub-angular blocky	Friable to firm with depth
Kuantan	Basalt	Strong brown to yellowish red	Clay to heavy clay	Moderate to strongly developed, medium granular and sub-angular blocky	Very friable
Segamat	Andesite	Yellowish red to red	Clay to heavy clay	Strongly developed medium sub-angular blocky	Very friable

TABLE 3.2 SOME SOIL SERIES IN RUBBER-GROWING AREAS OF PENINSULAR MALAYSIA (contd.)

Series	Parent material	Colour	Texture	Structure	Consistency
Kulai	Rhyolites and volcanic tuffs	Pale yellow brown to strong brown	Loam to silty clay	Weak, angular blocky	Firm
Yong Peng	Dacite	Strong brown to yellowish red	Clay loam to clay	Moderate, medium sub-angular blocky to strong angular blocky	Friable
Seremban	Schist	Reddish yellow to yellowish red	Fine sandy clay loam to fine sandy clay	Fine sandy clay loam to fine sand clay	Friable to firm
Batang Merbau	Schist and quartzite	Yellowish brown	Fine sandy loam to sandy clay loam	Moderate, medium sub-angular blocky	Friable to firm
Bungor	Quartzite or shale	Yellowish brown of brownish	Fine sandy clay loam to fine sandy clay	Strong, medium sub-angular blocky	Friable to firm
Serdang	Sandstone	Strong brown to yellowish yellow	Coarse sandy loam to sandy clay loam	Weak to moderate, fine and medium sub-angular blocky	Friable
Kedah	Quartzite and sandstone	Strong brown	Sandy loam to sandy clay	Weak to moderate, medium and fine sub-angular blocky	Friable to firm
Harimau	Older alluvium	Yellowish brown to brownish yellow	Sandy clay loam to sandy clay	Weak to moderate, medium sub-angular blocky	Friable to firm
Ulu Tiram	Older alluvium	Yellowish brown	Sandy clay loam to gravelly loam	Weak, medium crumbs to weak medium sub-angular blocky	Friable to firm
Tampoi	Older alluvium	Reddish yellow to yellowish red	Sandy loam to sandy clay loam	Weak crumbs to coarse sub-angular blocky	Friable to firm
Klau	Sub-recent alluvium	Yellowish brown to brownish yellow	Sandy clay loam to sandy clay	Weak to moderate, medium coarse sub-angular blocky	Friable to firm
Holyrood	Sub-recent alluvium	Yellowish brown	Sandy loam to sandy clay loam	Weak, fine sub-angular blocky	Very friable

TABLE 3.2 SOME SOIL SERIES IN RUBBER-GROWING AREAS OF PENINSULAR MALAYSIA (contd.)

Series	Parent material	Colour	Texture	Structure	Consistency
Sogomana	Sub-recent alluvium	Light grey to white	Silty clay to clay	Weak, coarse prismatic breaking to angular blocky	Firm
Sitiawan	Sub-recent alluvium	Pale yellow to yellow	Clay	Moderate, coarse angular blocky	Firm
Lunas	Sub-recent alluvium	Dark greyish brown to light grey	Coarse sand clay loam	Weak, fine crumbs to moderate weak, very coarse angular and sub-angular blocky	Very friable to firm
Sungai Buloh	Recent riverine alluvium	Dark brown to yellowish brown and yellow	Coarse sand	Structureless to weak, fine crumbs	Loose to very friable
Briah	Marine alluvium	Light brown to brownish grey	Silty clay loam or silty clay	Strong or moderate sub-angular blocky	Friable for with depth
Selangor	Marine alluvium	Dark greyish brown or greyish brown	Silty clay	Weak to moderate, coarse prismatic or angular blocky	Friable to firm with depth
Linau	Marine alluvium	Dark brown	Organic clay to muck with some decayed plant remains	Weakly structured	Friable to firm with depth
Senai	Gabbro	Brown to yellowish red	Clay	Moderate, fine and medium to moderate sub-angular	Friable to firm
Subang	Organic enriched alluvial deposit over compact sand	Dark brown to very pale brown	Organic sandy loam to sand	Strong, medium granular and sub-angular blocky to structureless	Friable
Organic clay and mucks	Organic deposits accumulation	Not fully investigated yet			
Peat	Organic deposits accumulation	Not fully investigated yet			

Soil Limitation

While some classes of soils have properties desirable for growth of rubber, the poor classes have properties which limit optimum growth and performance. The common limitations are as described below

Very serious limitations:

- Slopes steeper than 16 degrees
- Massive thick hard-pan within 23 cm of the surface
- More than 75% rock outcrops in a unit area
- Permanent water table within 23 cm of the surface
- Acid peat layer thicker than 23 cm
- More than 90% sand
- Very low nutrient level

Serious limitations:

- Slopes steeper than 9 degrees but below 16 degrees
- Massive thick hard-pan between 20-50 cm of surface
- Between 50 to 75% rock outcrops in a unit area
- Permanent water table between 20-50 cm of the surface
- Very compact soil
- Very sandy or clayey
- Susceptible to moisture stress
- Low nutrient level.

Less serious or minor limitations:

- Weak structure within 90 cm of surface
- Moderate drainage conditions
- Massive thick hard-pan below 50 cm from surface or loosely packed gravels within 50 cm from surface
- Less than 50% rock outcrops in a unit area
- Susceptible to flooding
- Susceptible to erosion
- Below optimum nutrient level.

Soil Limitation Classification

Based on the above information, the following soil limitation classifications are recommended for rubber cultivation:

- Class I - Having no limitation to rubber cultivation
- Class II - Having one or more limitations to rubber cultivation
- Class III - Having at least one serious limitation
- Class IV - Having more than one serious limitation for rubber cultivation
- Class V - Having at least one very serious limitation for rubber cultivation

Land suitability is also categorised into orders. Two orders are recognised - suitable (S) and unsuitable (N) for rubber cultivation. The sub-division are as follows:

- S1 - Highly suitable for rubber cultivation
- S2 - Moderately suitable for rubber cultivation
- S3 - Marginally suitable for rubber cultivation
- N1 - Currently unsuitable for rubber cultivation
- N2 - Permanently unsuitable for rubber cultivation

Soil Productivity Classification

Studies have shown that yield of rubber is dependent on soil properties. Munchong, Rengam and Jerangau series have good physical properties and therefore the yields are higher. Selangor and Briah series have very poor physical properties, and hence poor yield. The physical properties of Holyrood and Tampoi are said to be intermediate, thus, the yields are also intermediate. Based on the above information, soils are divided into five productivity classes (*Table 3.3*).

TABLE 3.3 SOIL PRODUCTIVITY CLASSES

Class	Yield category (kg/ha/year)	Soil series
IA	>1,350	Munchong, Prang, Kuantan, Segamat
IB	1,250-1,350	Rengam, Jerangau, Yong Peng, Bungor
II	1,150-1,250	Senai, Harimau, Batang Merbau, Subang, Klau, Serdang
III	1,050-1,150	Ulu Tiram, Pohoi, Holyrood, Lunas, Kuala Berang, Tampoi
IV	1,000-1,050	Batu Anam, Durian, Seremban, Melaka, Gajah Mati, Kedah, Marang
V	<1,000	Briah, Selangor, Sungai Buloh, Linau, Peat

Desirable Soil Properties for Rubber Cultivation

Soils have different physical, chemical and physiographical combinations. Their suitabilities for rubber cultivation also vary. The desirable properties for rubber cultivation are listed below:

- Soil depth of up to 100 cm
- Well drained
- Good soil aeration
- Good structure
- Able to retain water and nutrients
- Good texture - 35% clay and 30% sand
- No peat or peat layer not thicker than 23 cm
- Slopes not exceeding 16 degrees
- Water table deeper than 100 cm from surface
- At least medium status of NPKMg
- Not deficient in minor nutrients
- Level of pH around 4.5
- Not saline or no acid sulphate

Agro-management Practices to Overcome Soil Limitations

Different specific agro-management practices and inputs are required on different soils as a result of their limitations. These are summarised below:

- Establishment of pure creeping legume cover crops for all situations
- Terracing for slopes exceeding 16%
- Silt-pittings or bundings for slopes below 16%
- Contour ploughing only for slopes below 16%
- Contour planting on slopes of 2-8%
- Efficient drainage system for high water table clay soils
- If mechanical ploughing is intended for heavy clay textured soils, it must be carried out at the correct soil moisture content
- Avoid heavy crown clones for high water table areas, sandy and lateritic soils
- Carry out extra and split application of fertilisers for the sandy textured and peaty soils

SOIL CONSERVATION

Soil conservation can be considered as maintaining, protecting, and improving the soil for agricultural purposes. Crop productivity depends very much on the top soil, where plant nutrients are concentrated. As this rich layer is at the top of the soil surface, plant nutrients can easily be lost, removed or damaged by various natural processes.

Objectives of Soil Conservation

The objectives of soil conservation are therefore to:

- reduce soil erosion
- maintain and improve soil structure
- maintain organic material content in the soil
- utilise efficiently available water
- maintain soil fertility by reducing nutrient loss, and to replace those that are lost

Soil Erosion and Its Consequences

Soil erosion is a natural process in which loss of rich top soil occurs by the action of rain, wind and sunlight. In the tropics, due to abundant rainfall, much of the erosion is caused by water. The degree of erosion then depends greatly on the amount of rainfall and the steepness of the terrain.

When erosion occurs, the nutrient-rich top soil is washed away. This can affect plant growth and later, its yield. In areas where the terrain is too steep, more serious consequences can take place, such as exposure of tree crop roots followed by falling trees.

Types of Erosion

There are two main types of erosion, the geological and the accelerated erosion. Geological erosion is the erosion of land in its natural environment, without man's influence. It occurs naturally by the action of rain, wind, temperature variations, gravity and vegetation. In fact the present land relief of Malaysia is the result of geological erosion. It is an on-going process, and there is nothing much that we can do about it.

Accelerated erosion is mainly caused by man in his effort to bring about development by land clearing. Still, the chief agent of accelerated erosion is water. The various types of water erosion are discussed below:

Sheet erosion. Sheet erosion is the uniform removal of a thin layer or sheet of top soil, by falling rain, followed by surface run-off removal. Usually it takes place unnoticed. It occurs on smooth surface and on uniform or regular slopes.

Rill erosion. In their natural form, most soil surfaces are irregular with low and high places, such as runnels, furrows and mounds. When rain falls, water flows into depressions causing rill formation. The eroded soil surface can become deeper with time, leading to the formation of gully erosion (*Figure 3.4 a*).

Gully erosion. Gully erosion is a more serious form of rill erosion. The soil surface becomes so deformed, with large ugly-looking scars, which sometimes make agricultural development almost impossible (*Figure 3.4 b*).

Landslide. Landslide can be considered as a more serious form of gully erosion. Besides destroying the soil fertility, it causes damage to crops, properties, waterways, highways and probably lives, too. It normally occurs on very steep slopes of hills undergoing development and road cuttings. It causes the detachment of huge blocks of soil from the main hill during heavy and prolonged rainfall (*Figure 3.4 c*).

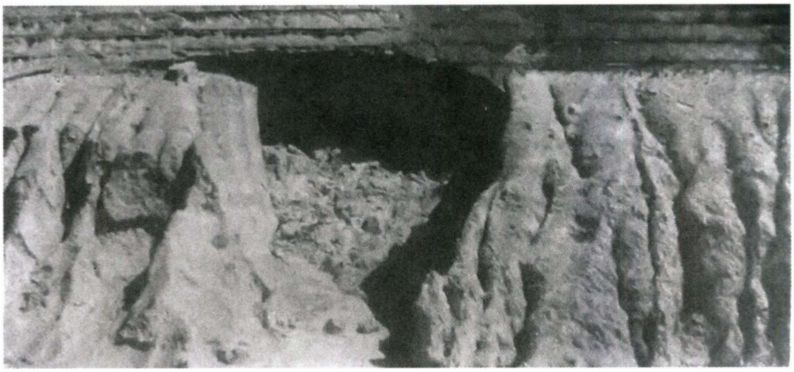
Minimising Soil Erosion

Soil erosion can be minimised by reducing the speed of running water and at the same time encouraging it to penetrate the soil, thus reducing surface run-off. Protecting the soil surface from direct rainfall, wind and sunlight also helps to reduce erosion. Steps to be considered to minimise the dangers of erosion are:

- Contour terracing for slopes exceeding 11 degrees
- Contour bunding for slopes below 11 degrees
- Contour platforming for slopes below 11 degrees
- Contour silt-pitting for slopes below 11 degrees
- Contour ploughing where required
- Contour planting where necessary
- Mulching around crops
- Cover cropping for all land situations (*Figure 3.5 and Table 3.4)*

a) Rill erosion

b) Gully erosion



c) Landslide erosion

Figure 3.4 Various types of soil erosion

(a) Contour terracing

(b) Contour bunding

Figure 3.5 Contour terracing and bunding

TABLE 3.4 EFFECT OF COVER CROPS ON REDUCTION OF SOIL EROSION

Type of soil	Quantity of rain (cm)	Quantity of soil eroded (tonne/ha)		
		Exposed*	Grassed	*Nephrolepis***
Rengam 4° - 5°	292	103	44	Negligible
Serdang 3° - 5°	325	132	177	59

* Bare land surface or no vegetation at all

** A type of fern

Soil Tillage

Although no tilling is required for rubber cultivation, ploughing and harrowing can be carried out, if short term crops are to be inter-grown. The main aim of tilling is to reduce the compactness of the soil to facilitate root development at the initial stage of plant growth. But the soil can become compact, if ploughing is not properly carried out. If the soil is ploughed after a heavy downpour, it becomes more compact and hard. The soil must be allowed to dry sufficiently. As a guide, sandy soils such as the Sungai Buloh, Holyrood and Serdang series, can be ploughed two to three days after rainfall, while the medium soils (Rengam and Munchong series), four to five days and the clayey soils (Sitiawan dan Sogomana series), one week.

Manuring

Soil fertility has become the main factor in soil management. By maintaining high soil fertility, several conditions which assist in reducing erosion can be achieved. Good plant growth rate which covers the soil surface, also reduces rainsplash, surface run-off and at the same time preserve water in the soil for plant/crop usage. To achieve a high level of fertility, correct fertiliser must be adequately applied. This can be determined by soil and foliar analysis, fertiliser trials and crop growth survey. Such efforts can lead to a more specific fertiliser application known as discriminatory fertiliser usage.

In crop cultivation, soil fertility is of utmost importance because; it determines the viability of the crop. Below are several factors concerning soil management that are considered important.

- Knowing the most suitable time to carry out land development for rubber cultivation - planning, clearing, tilling, planting and others
- Reducing soil erosion to the maximum
- Utilising available organic fertiliser to the maximum
- Increasing nutrient status of the soil by the use of chemical fertilisers
- Mulching around crop where possible and suitable
- Maintaining pure legume covers to the very end of their life cycles

TERRACING

Terracing is the cutting of steps or paths horizontally on hill slopes following their contours. Terraces function as planting rows on hill slopes, since planting of rubber is done on and along them.

Objectives of Terracing

The objectives of constructing terraces on hill slopes are to:

- reduce soil erosion
- retain and preserve water in the soil
- facilitate holing and planting operations
- facilitate manuring
- facilitate general field maintenance
- facilitate movements on hill slopes

Method of Terracing

Terraces are constructed along contour lines marked out during field lining. This is to ensure that they are level. A cut is made into the hill slope, about 60 cm above or below the contour line, and the earth is pulled backward (downhill) to create a path of 1-1.5 m wide. This cut is continued to the end of the contour line. The spoil is heaped along the lower edge of the slope and given a beating to form a strong bund. The terrace should slope inward into the hill with a back drop of 25-30 cm from the horizontal or declining 10-20°, depending on the slope gradient (*Figure 3.6*). At intervals of 8 m along the terraces, earth-stops are made to check lateral flow of water, by leaving 30 cm width of uncut earth. Thirty metres of terrace length can be completed per man-day. For a large area mechanical terracing is more appropriate. A light bulldozer such as the *D4 model* fitted with a tilting blade that can cut 2-4 m width of terrace at the rate 100 m per hour is normally used. Earth-stop at 20 m intervals are sufficient for such terraces.

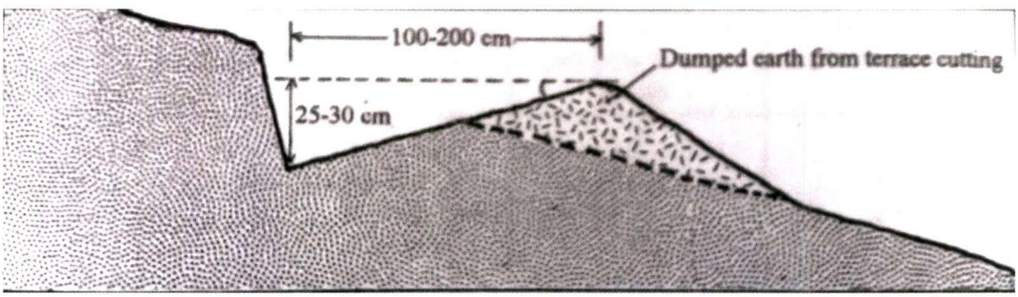


Figure 3.6 Cross-section of terrace

The total length of terraces in a hectare of hilly area can be calculated, if the average distance between terraces is known, by the following formula:

$$\text{Total Length of Terrace} = \frac{\text{Area per hectare (m}^2\text{)}}{\text{Average distance between terraces (m)}}$$

Fixing Planting Points

In view of the irregularity of the distances between terraces, it is advisable to make adjustments to the planting points (from the original distance of 2.5 m) where necessary for a more uniform planting density per hectare. This can be achieved by marking off all the terraces at 20 m intervals. At the beginning and end of every 20 m along the terraces, the horizontal distance between adjoining terraces is measured orthogonally (*Figure 3.7*). The measurements are then summed up, and in reference to *Table 3.5*, the planting distance along the 20 m mark is obtained, based on the planting density of 500 plants per hectare.

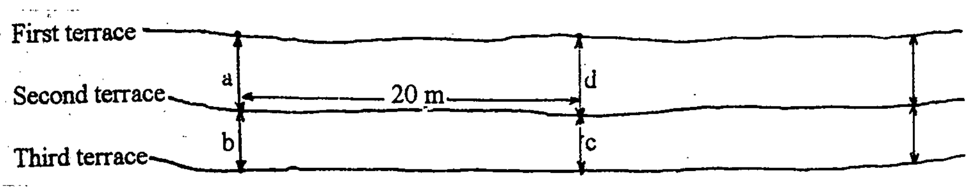


Figure 3.7 Layout for planting point adjustment along terrace

TABLE 3.5 PLANTING POINTS FOR 500 PLANTS PER HECTARE ON TERRACE

Sum of a,b,c,d (m)	Average horizontal distances between terraces (m)	Number of plants per 20 m terrace length	Distance between planting points (m)
24.3-27.2	6.1-6.8	5	4.00
27.3-32.1	6.9-8.0	6	3.33
32.2-37.0	8.1-9.2	7	2.86
37.1-41.9	9.3-10.5	8	2.50
42.0-46.7	10.6-11.7	9	2.22
46.8-48.9	11.8-12.3	10	2.0

GROUND COVER CROPS

In agricultural practices, exposed soil surface is most undesirable, as it can cause much damage to the top soil, rendering it no longer suitable for growing crops. The main planted crop, such as rubber, is insufficient to provide full coverage to the soil surface, especially during the first few years of establishment. Plants which are more densely populated are needed to perform such function. They are known as ground cover plants or ground covers. Ground covers can be defined as small plants, either planted or self-grown such as weeds, catch crops and leguminous plants.

Weeds

Weeds can be defined as plants which are self-grown. Desirable weeds are those that utilise very little nutrients from the soil, but grow vigorously and return lots of green litter to the soil. Undesirable weeds are those that take up lots of nutrient but return very little litter to the soil. Most grasses, bracken, sedges and others come under this category of weeds. Among them, *Imperata cylindrica* and *Mikania micrantha* are regarded as very harmful to rubber growth. Their roots are believed to release toxic substance that inhibits growth of rubber. Only the desirable weeds should therefore be allowed to grow in the rubber plantation, while the undesirables are eradicated.

Catch Crops

Catch crops are short term crops, usually grown between rubber planting rows. They are mostly food crops, such as maize, groundnuts, soya bean, vegetables and others. They are able to provide temporary income to the farmers and at the same time function as cover crops. Such practice is only suitable during the first two or three years of rubber cultivation, because of the shading effect from rubber trees.

Leguminous Plants

Leguminous plants *(Leguminoseae sp.)* are those that can fix atmospheric nitrogen and convert it to nitrates, through the bacteria present in the root nodules of such plants. From the soil fertility point of view, this type of ground cover is most preferred. Legume covers are divided into two groups namely creepers and non-creepers. Non-creepers are further divided into bushy and prostrates (*Table 3.6*).

TABLE 3.6 SOME COMMON LEGUME COVER PLANT SPECIES

Creepers	Non-creepers	
	Bushy	Prostrates
Calopogonium mucunoides	*Moghania macrophylla*	*Stylosanthes gracilis*
Calopogonium caeruleum	*Tephrosia candida*	*Desmodium ovalifolium*
Centrosema pubescens	*Acasua villosa*	*Desmodium groides*
Pueraria phaseoloides	*Crotalaria anagroides*	*Classia obtusifolia*
Mucuna cochinchinensis	*Crotalaria striata*	*Mimosa invisa*
Phaseolus pubescens	*Leucaena glauca*	
Clitoria rubigonosa		

Among the legume covers, the creepers are preferred, as they cover the soil surface very fast. Their detailed descriptions are given in the later part of this Chapter.

Advantages of creeping legume covers. Numerous advantages can be obtained by establishing creeping leguminous covers in the rubber plantations, and they are listed below:

- Protect the soil surface, thus reducing soil erosion and direct sunlight (*Table 3.7*)
- Assist in the preservation of water in the soil
- Reduce soil temperature, thus delaying the decomposition of organic matter
- Help to loosen the soil and facilitate aeration and drainage in the soil
- Improve soil structure and other related physical properties
- Add organic matter to the soil in the form of leaf litter
- Fix atmospheric nitrogen and convert it to nitrate for plant usage
- Encourage feeder root development near the soil surface, hence more efficient uptake of nutrients *(Table 3.8)*
- Provide good nitrogen nutrition to rubber during the first two to five years of growth (*Table 3.9*)
- Reduce cost in nitrogenous fertiliser
- Reduce leaching losses of nutrients deep into the soil
- Enhance growth of rubber, resulting in early maturity (*Tables 3.10-3.11*)
- Increase crop yield (*Table 3.12*)
- Improve bark renewal
- Help to suppress weeds growth and thus reduce cost of weed control
- Reduce overall field maintenance of rubber plantation
- Assist in faster decomposition of old tree stumps, thus reducing root disease incidence in young plantings

TABLE 3.7 EFFECT OF COVER CROPS ON SOIL EROSION

Type of cover	Thickness of soil accumulated on terrace (cm)
Pueraria phaseoloides	11.0
Grasses	12.5
Tephrosia candida	14.0
Crotalaria anagroides	15.5
Exposed *	19.0

*No covers at all

TABLE 3.8 EFFECT OF COVERS ON FEEDER ROOT DEVELOPMENT OF RUBBER

Type of cover	Weight of feeder roots (mg/1000 cc soil)
Legume	623
Grasses	330
Mikania	251

TABLE 3.9 NUTRIENTS RETURNED TO THE SOIL IN FIVE YEARS BY TWO TYPES OF COVERS (KG/HA)

Type of cover	N	P	K	Mg
Legume	226-535	18-27	85-131	15-27
Grasses	24-65	31-16	31-86	5-9

TABLE 3.10 EFFECT OF COVERS ON GROWTH OF RUBBER FIVE YEARS AFTER PLANTING (CM)

Type of cover	Inland soil	Coastal clay soil
Legume	40	41
Grasses	36	40
Imperata cylindrica	18	24

TABLE 3.11 EFFECT OF COVERS ON THE IMMATURITY PERIOD OF RUBBER

Type of cover	Seremban series soil (months after planting)	Melaka series soil (months after budding)
Legume	61	56
Grasses	68	59

TABLE 3.12 EFFECT OF COVERS ON THE ACCUMULATED YIELD OF RUBBER (KG/HA)

Type of cover	148 months	159 months
Legume	10,145	11,843
Grasses	8,220	10,449

Disadvantages of legume creeping covers. Legume creeping covers also pose some drawbacks in rubber plantation. As living plants, they too compete with rubber for nutrient and water from the soil, space, sunlight and air. They provide sanctuary for certain rubber pests such as molluscs and insects. In view of their creeping nature, they climb up the rubber plants, choking and bending them. But the abundant advantages they give to rubber offset these disadvantages.

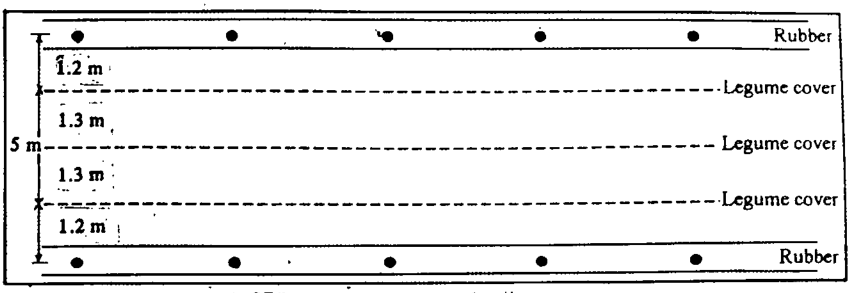
Legume cover species. There are several species of creeping legumes, but only five are commonly planted in rubber plantations. *Calopogonium mucunoides* has medium size oval-shaped leaves and small-size seeds. It establishes very fast, but has a life span of below two years. *Centrosema pubescens* has small leaves, but larger seeds. It is slow to establish, but tolerates shade. *Pueraria phaseoloides* has large broad leaves and smallest seeds. It establishes fast and tolerates shade. *Calopogonium caeruleum* has also medium-size leaves, medium-size and flat seeds and is the most shade tolerant of all. *Mucuna cochinchinensis* has very large broad-shaped leaves and extra large seeds, it is very vigorous in growth but has a life span of below one year . To obtain a good ground cover with all the growth properties present, a mixture of the different species is recommended (*Table 3.13*).

TABLE 3.13 LEGUME COVER CROP SEED MIXTURES (KG/HA)*

Legume species	Mixture A	Mixture B	Mixture C
Calopogonium mucunoides	2.9	4.1	1.8
Centrosema pubescens	1.2	-	-
Pueraria Phaseoloides	1.9	1.2	2.3
Calopogonium caeruleum	-	0.7	0.7
Mucuna cochinchinensis	-	-	1.2

*Based on 80% germination, quantity to be increased accordingly if germination rate is lower

Method of planting. For planting of legume covers, the land area must first be cleared and lined. On hill slopes terraces must be completed. V-shaped drills 2.5 cm deep are cut in the soil between rubber planting rows or terraces, the number of drills depending on the distance between the planting rows. The distance of the drills nearest to the planting rows should be 1.2 m and the distance between drills should be 1-3 metres. For example, three drills are suggested between 5 m inter-rows, and four drills between terraces of 8 metres *(Figure 3.8)*. On a hill slope, the top-most drill is laid along the terrace lip to provide protection along the filled portion of the terrace . Rock phosphate at 125 kg per hectare is applied in the drills.



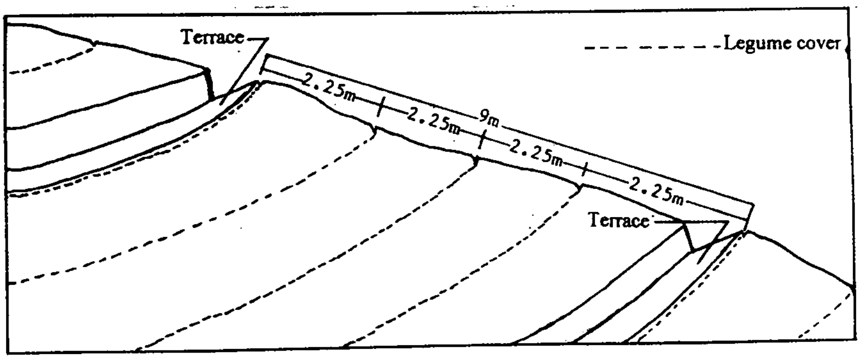


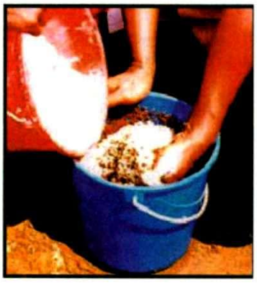
Figure 3.8 Plan of legume cover crop drills for flat land (above) and hill slope (below)

(a) Soaking seeds in hot water

(b) Preparing cultivated drills

(c) Applying rock phosphate in the drills

(d) Innoculating seeds with *Rhizobium* compost



(e) Mixing seeds with rock phosphate

(f) Sowing seeds into the drills

(g) Covering the seeds

(h) Blanket spraying of pre-emergent herbicides

Figure 3.9 Planting out legume cover crop seeds

The seeds are mixed in a suitable container. They are then soaked in hot water at 75 °C (one part of cold water in two parts of boiling water) for two hours. After removing excess water, the seeds are innoculated with *Rhizobium* compost at 10 kg per 50 g packet of the compost. The treated seeds are then mixed with equal weight of rock phosphate. The seeds are sown in the drills and lightly covered with soil. Immediately after planting, pre-emergent herbicide, such as *Lasso* at 3 litres in 450 litres of water per hectare is blanket-sprayed *(Figure 3.9)*.

Maintenance of legume covers. After three to four weeks, work on legume cover purification must begin by manually removing weeds that emerge. Compound fertiliser containing NPKMg at 15:15:6:4% is applied on the covers at 63 kg per hectare *(Figure 3.10)*. When the legumes have provided 10-20% coverage, the weeds are controlled by herbicides, such as 2.5 litres *Paraquat* + 1.2 litres *Velpar K-51* in 450 litres of water per hectare.

Pests of legume covers such as slugs and snails are controlled by poisoned bait, while the insect pests are controlled by spraying insecticides such as 48 g *Dipterex SP* or *Sevin 85S* in 20 litres of water.

Rock phosphate is again dusted over the legume cover crops at 250 kg/ha/ year, when they are one, three and eight months old, and thereafter, annually. Legume cover crops are expected to be fully established in less than a year *(Figure 3.10)*.

(a) Applying NPKMg compound fertilisers

(b) Dusting rock phosphate

Figure 3.10 Manuring legume cover crops

Through breeding and selection, MRB succeded in developing a selection of latex-timber clones that excellent in rubber production as well as rubberwood production

CHAPTER 4

PLANTATION DEVELOPMENT

Rubber plantation development is a huge undertaking as its operations involve labour force and agricultural machinery. The complexity depends on the size of the land area to be developed as completion of each field operation must coincide with the season. In Malaysia, rubber planting can be divided into two types *i.e.* new planting and replanting.

New planting is defined as planting of rubber in an area where rubber was never planted before. Usually, this area is jungle land which is suitable for agriculture and where useful timber had been extracted. The land could also have been planted with other crops and is now undergoing agricultural diversification. Individual new plantings for smallholders are almost non-existent today, except in isolated cases of pocket land alienation. Most of the new plantings are carried out in large scale by the government development agencies. Financial resources for such development come from Government grants, commercial financial institutions, the World Bank and the Asian Development Bank.

Replanting is defined as planting of rubber in an area already planted with the same crop with the aim of replacing the old uneconomic trees with high quality planting materials. In 1951, the Government initiated a replanting scheme to rehabilitate uneconomic rubber areas. The scheme is financed by a special cess collected from rubber exported; currently at 9.92 sen per kilogramme, plus a special Government grant. The implementing agency for this project is RISDA. Smallholdings are normally replanted individually, but now RISDA prefers them to be grouped in block basis with good and efficient management back-up to ensure greater rate of success.

WORK OPERATIONS

Plantation development work operations are numerous, from the major to the minor ones. As there are two types of rubber planting, their field operations also differ, especially in the land clearing work.

New planting. For new planting, the following work operations are normally required to be carried out:

- Constructing drainage (if necessary)
- Underbrushing of ground vegetation
- Felling of jungle trees by chainsaw cutting or by bulldozing
- Drying of felled timber
- Burning – primary burning
- Pruning and stacking
- Burning – secondary burning
- Constructing agricultural road (if necessary)
- Tilling (if necessary)
- Field lining – straight or contour
- Terracing (if necessary)
- Establishing legume cover crops
- Holing
- Perimeter fencing (if necessary)
- Transplanting of polybag rubber planting materials

Replanting. For replanting, the following work operations are normally required:

- Underbrushing or blanket chemical spraying of ground vegetation
- Felling of old rubber stand by chainsaw cutting and poisoning of stumps

Or

- Poisoning old rubber stand to facilitate rotting

Or

- Felling (uprooting) of old rubber stand by bulldozing or mechanical winching
- Removing felled rubberwood

Or

- Drying of felled rubberwood
- Burning – primary burning
- Pruning and stacking
- Burning – secondary burning
- Constructing drainage (if necessary) or servicing existing drainage system
- Constructing agricultural roads (if required) or servicing existing ones
- Tilling (if necessary)

- Field lining – straight or contour
- Terracing (if necessary) or servicing existing ones
- Establishing legume cover crops
- Holing
- Perimeter fencing (if necessary)
- Transplanting of polybag planting materials

Work Schedule

In plantation development, it is most important to draw up a work programme, showing the works to be carried out and the times for their completion (*Tables 4.1 and 4.2*). This is because all land preparations must be completed before the main rainfall season begins, when it is most suitable to carry out transplanting of rubber. The main rainfall season in Peninsular Malaysia is usually from October to December. This may differ from state to state by a month either earlier or later.

Development Cost

The development costs for new planting and replanting are almost the same. Perhaps, the initial land clearing for the new planting may be higher as it involves the clearing of thick vegetation, whereas in a replanting, only some 300 old rubber trees per hectare have to be dealt with. Moreover, a replanting can obtain additional income from the sale of rubber timber, which is in great demand these days, thus reducing further its development cost. Other aspects of field operations that can increase the development cost are terracing and drainage. Plantation development cost, from land clearing to crop maturity, are detailed in *Tables 4.3 and 4.4.*

Land Clearing

All living plants need enough nutrients, water, air, sunlight and space in order to survive and grow vigorously. These also apply to crops such as rubber. Other forms of vegetation around them pose as competitors. The lesser the competitors, the better will be the growth of the planted crops. Therefore, for plantation development, jungle and old rubber areas must be cleared of all vegetations, before planting is carried out. Some of the existing vegetations, especially old rubber trees, may have been hosts to root disease fungus. Therefore, removing them first may help eliminate or reduce root disease in young plantings later on. Again, cleared and cleaned areas facilitate land preparation work such as lining, terracing, holing and planting.

TABLE 4.1 SAMPLE WORK SCEHEDULE FOR 2,000 HA NEW PLANTING

Work operation	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Demarcating block														
Underbrushing, felling and drying														
Burning - Primary														
Pruning, stacking and reburning														
Constructing drainage														
Constructing roads and terracing														
Holing and fencing														
Establishing legume covers														
Transplanting rubber														

TABLE 4.2 SAMPLE WORK SCHEDULE FOR 50 HA REPLANTING*

Work operation	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bulldozing and removing timber											
Burning of left-over debris											
Servicing of old road											
Lining and terracing											
Holing											
Establishing legume cover crops											
Transplanting polybag materials											

*A hilly area at RRIES, Sungai Buloh (1990) that needs 10% terracing

TABLE 4.3 RUBBER NEW PLANTING COST (RM/HA)*

Work Operation	Year							Total	%
	0	1	2	3	4	5	6		
Land Clearing	720.00	180.00						900.00	6.0
Terracing@500m/ha	600.00	125.00						725.00	4.9
Lining and holing	510.00							510.00	3.4
Planting and maintenance of legume covers	600.00	100.00						700.00	4.7
Planting materials	1,215.00							1,215.00	8.1
Planting labour (inclusive transport)	540.00							540.00	3.6
Replacement	121.50	36.50	36.50					194.50	1.3
Weeding		416.00	333.00	187.00	187.00	104.00	104.00	1,331.00	8.9
Manuring		606.00	819.00	716.00	1,050.00	1,040.00	1,040.00	5,271.00	35.3
Disease and pest control		60.00	40.00	80.00	70.00	20.00	20.00	290.00	1.9
Pruning/census/thinning			335.00	70.00	70.00	35.00		510.00	3.4
Roads and bridges	450.00	350.00	100.00	70.00	50.00	100.00	120.00	1,240.00	8.3
Drainage@10m/ha	30.00	30.00	5.00	40.00	10.00			115.00	0.8
Proportion of general charges (supervision/sundry expenses/other costs)	200.00	200.00	200.00	200.00	200.00	200.00	200.00	1,400.00	9.4
Total	**4,986.50**	**2,103.50**	**1,868.50**	**1,363.00**	**1,637.00**	**1,499.00**	**1,484.00**	**14,941.50**	100.0

Note :
1. 450 trees/ha
2. Chemical and Fertilizer price as at January 2009
3. Terracing@40% of total area.

Table 4.4 RUBBER REPLANTING COST (RM/HA)*

Work Operation	Year						Total	%
	0	1	2	3	4	5		
Land Clearing	600.00						600.00	5.1
Reterracing	180.00	100.00					280.00	2.4
Lining and holing	480.00						480.00	4.1
Planting and maintenance of legume covers	600.00	100.00					700.00	5.9
Planting materials	1,215.00						1,215.00	10.3
Planting labour (transport included)	540.00						540.00	4.6
Replacement	121.50	36.45	36.45				194.40	1.6
Manuring		606.00	819.00	716.00	1,050.00	1,040.00	4,231.00	35.8
Weed control		416.00	333.00	187.00	187.00	104.00	1,227.00	10.4
Disease and pest control		60.00	40.00	80.00	70.00	20.00	270.00	2.3
Pruning/census/thinning		45.00	45.00	60.00	10.00	10.00	170.00	1.4
Roads and bridges maintenance	240.00	60.00	60.00	50.00	50.00	120.00	580.00	4.9
Drainage maintenance	30.00	30.00	5.00	40.00	10.00		115.00	1.0
Proportion of general charges (sundry expenditure/ supervision/ other costs)	200.00	200.00	200.00	200.00	200.00	200.00	1,200.00	10.2
Total	**4,206.50**	**1,653.45**	**1,538.45**	**1,333.00**	**1,577.00**	**1,494.00**	**11,802.40**	100.0

Note :
1. 450 trees/ha
2. Chemical and Fertilizer price as at January 2009

Clearing of Jungle Land

Jungle clearing *(Figure 4.1(a))* is carried out either by manual felling or mechanical uprooting. These are described below.

Manual felling. First of all, the area to be cleared is demarcated. A rentis of 2 mm width is cut around the boundary. For a very large area, it is advisable to divide it into smaller blocks of, say 40-80 hectares. Clearing work is then done block by block to facilitate supervision, in which case, each block is clearly demarcated by such rentice as mentioned earlier. Underbrushing is done to all ground vegetation. They are spread at the same thickness on the ground to help in the burning process later on. Jungle trees are then felled by chainsaw. The height of cutting varies from 15 cm to the buttress, depending on the size of the trunk. The trees should be felled in one direction to facilitate burning. Felling trees across roads, ravines, and swamps must be avoided. Usually a group of four to five trees close together is felled, the largest of them chosen as the kingpin. Wedge-shaped cuts are made on one side of the rest of the trees in the group facing the direction to be felled. Then a complete cut is made to the kingpin, and when it falls, it knocks down the rest of the trees in the group. Large branches are pruned off to create a compact condition of the felled timber and to facilitate good burning. The trunks of felled timber are cut into two or three pieces. It is always advisable to create a fire belt of 20-40 m wide around the area. Trees in the fire belt are left standing to act as fire breakers. Such belt is felled and burnt when the inner area has been completely cleared and burnt.

Burning can be carried out as soon as the felled timber is dry. This takes about two months. However, there should be no rain within three to four days prior to burning. Ten fire points are required for every hectare and they should be placed at the edge of the area to be burnt so that the direction of burning is from outside towards the inside and finally to the centre. Suitable materials for fire starters should be used. Burning should preferably start at noon when conditions are dry. Every precaution must be taken with regards to safety. Pruning of the smaller unburnt logs, stacking and reburning them can be carried out as soon as the burnt area is safe enough to enter (*Figure 4.1(b)*). However, it must be emphasised here that open burning of jungle land for conversion to agriculture land requires a licence from the Department of the Environment (DOE) under Section 22(1) of the Environmental Quality Act 1974.

Mechanical clearing. As mentioned earlier, new plantings are mostly done on large scales with the aid of machinery to complete the operation on time. Bulldozers are used to push down and uproot jungle trees which are then piled in wind-rows at intervals of some 10-20 metres. They are later burnt when adequately dry, and the same procedure described earlier is applied. When using this method, underbrushing of ground vegetation is normally not done, as it will be destroyed along with the felled timber.

(a) Jungle area before clearing

(b) Cleared jungle land ready for rubber cultivation

Figure 4.1 Manually-cleared jungle area for rubber cultivation

Clearing Old Rubber Area

There are three options for clearing old rubber areas for replanting. These are manual felling, mechanical uprooting and poisoning. The details are given below.

Manual felling. As usual, underbrushing of ground vegetation is done first. The old rubber trees are felled by chainsaw in one direction. Felling across roads, streams and swamps must be avoided. Large branches are pruned off and the trunks shortened into two or three logs. The cut surfaces on the stumps are painted with creosote to prevent root disease spore colonisation, while around the stumps, arboricide such as Trichlopyr *(Garlon 250)* at 5% concentration in kerosene or diesel, is applied to hasten decay (*Figure 4.2*). The timber logs are either taken out for commercial use or left to dry and burnt. Drying of rubber timber takes only about one month and the same burning technique described for jungle clearing is applicable.

Mechanical felling. Old rubber trees can be uprooted by bulldozer or backhoe or even by lorry-mounted winch *(Figure 4.2)*. The large branches are pruned off and the trunks are cut into logs. The logs are either taken out for other uses or pushed in wind-rows to dry and later burnt. A bulldozer is able to uproot approximately 1,200-2,000 trees a day.

(a) Uprooting by bulldozer

(b) Uprooting by lorry-mounted winch

(c) Felled rubber trees stacked in wind-rows

Figure 4.2 Clearing old rubber area for replanting

In the case of replanting, open burnings are allowed only on felled tree stumps that cannot be used or recycled for any other purposes. However, efforts must be made to reduce the quantity of materials to be burnt. The nearest DOE office must first be informed of such activities. It must be emphasised here that where possible, the concept of zero burning must be practised.

(a) After the valuable rubberwood has been recovered, the remaining debris is stacked and allowed to decompose naturally

(b) Gradual rotting and decomposition continued after transplanting

Figure 4.3 Zero burning replanting

Poisoning. Old rubber trees can be destroyed by poisoning with suitable arboricide such as Trichlopyr *(Garlon 250)*. A 5% concentration is prepared by diluting *Garlon 250* in four parts of kerosene or diesel. The part of the tree that is to be treated must be cleaned of rubber scraps and flaking bark. The arboricide is sprayed or brushed evenly over the bark on a band of 40-cm width around the base of the tree. The tree will be killed in about 18 months. One litre of the diluted chemical is sufficient to treat five trees. The trees are left to rot gradually (*Figure 4.3*). The ground vegetation (weeds) should be given a blanket spray of suitable herbicides. The rest of the field work operations can start as soon as the ground vegetation withers. This technique offers the following advantages.

- Zero burning is practised
- Very useful in areas where the rubber timber cannot be taken out for downstream usage
- Root disease incidence can be eliminated or reduced
- Carrying out land preparation work under shade is more comfortable
- Soil erosion is very much reduced
- Soil fertility is maintained or even enhanced from the decayed biomass
- Growth of rubber can be enhanced and early maturity expected
- Cost of plantation development can be reduced to a certain extent

Drainage

All living plants need water to survive. However, excess water limits aeration in the soil and upsets the breathing of roots. This can affect growth, and if this condition is prolonged, death of young plants can occur. Drainage can, therefore, be defined as draining or removing excess water in the soil. It is transferred to another area or lowered deep into the soil, or both.

Objectives of Drainage

Drainage is essential in the rubber plantation. Its objectives are to:

- remove excess water in the soil
- ensure that the soil water table is not less than 100 cm from surface
- ensure there is sufficient water in the soil for crop usage
- enable plants to obtain sufficient soil air
- maintain healthy growth of crops
- increase crop yield *(Table 4.5)*
- prevent diseases connected with stagnant water condition of soil

TABLE 4.5 EFFECT OF DRAINAGE ON YIELD OF CLONE PB 86 ON SELANGOR SERIES SOIL

Depth of drain (cm)	Year of planting	Average cumulative yield from second to seventh year (kg/ha)
50	1957/1958	5,825
100	1957/1958	7,155

Construction of Drains

There are two types of soil that need drainage – soil with high water table such as the coastal clay and inland soils, which are not permeable and cause water to stagnate, such as Batu Anam series. In order to determine whether a particular area needs drainage, a hole is dug in the soil and the water table is measured. A well-drained soil has no water up to 100 cm from the surface. Sometimes, it is difficult to determine this during dry weather. If the soil is of bluish grey to greenish grey, it shows that it needs drainage. Signs of rust or mottling in the soil indicate that the water table has risen to that level during rainy season. If such mottling layer is found 20-30 cm of the soil surface, the area needs drainage.

The outlet, through which excess water is drained, must first be determined. This can be a river, stream or lake; if there are no outlets, one must be constructed at the lowest part of the area. Main drains of 150 cm deep are dug at 100-200 m intervals running in the direction of the outlet. This is followed by subsidiary drains 120 cm deep at intervals of 50 m running towards the main drains. Intermediate drains 100 cm deep are dug between the subsidiary drains, also running towards the main drains (*Figure 4.4*). To obtain a fast flow of water, all drains must have a drop of 30 cm for every 300 m length. Drains can be constructed by manual digging or by mechanical back-hoe. *Table 4.6* gives the specifications of various types of drains mentioned above.

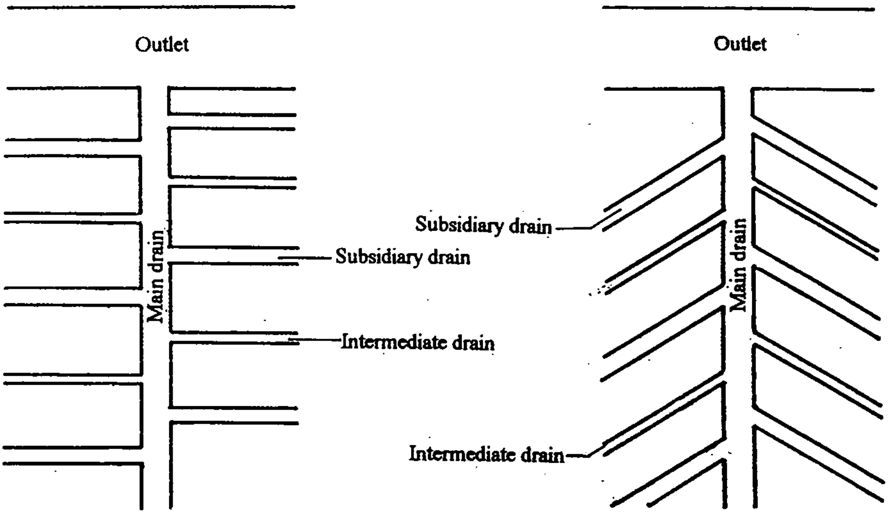


Figure 4.4 Plan of plantation drainage

TABLE 4.6 PLANTATION DRAIN SPECIFICATIONS

Type of drain	Top width (cm)	Bottom width (cm)	Depth (cm)	Length per man-day (m)
Main	150	100	150	5
Subsidiary	120	80	120	7
Intermediate	100	60	60	10

Maintenance of Drains

Plantation drains must always be functional. This can be achieved by regular maintenance. Drains must be desilted to their original depths from time to time so that the water table is kept to minimum level. Drains must be cleared of weeds growing in them so that flow of water is not hindered and there is no overflow during heavy rainfall.

Plantation Roads

Today, a road system, including those in the plantation, is an important part of the infrastructure. Movements of people, produces and vehicles must be fast enough so as to maintain all deliveries and schedules on time. A good road system is considered another sign of progress.

Objectives of Road System in a Plantation

The objectives of a well-planned and well-constructed plantation road system are to:

- maximise the general efficiency of all activities undertaken by the plantation
- facilitate communications
- facilitate supervision of all field activities
- facilitate transportation of people, goods and materials within the plantation and the outside connections
- reduce travelling time within the plantation
- reduce production cost of the plantation

Categories of Plantation Road

In large plantation companies, normally, there are three categories of roads. They are:

- The main road - connecting the main or parent plantation or headquarters and the normal public road
- Subsidiary road - connecting the headquarters with the various divisions
- Minor road - connecting field blocks in the plantation with the headquarters.

The above road categories do not always exist in all plantations. Sometimes, there are two categories and at other locations, only one, depending on the size of the plantation. For example, a small plantation will only have two categories of road - the main and the minor roads, while a 3-ha smallholding within a smallholding community may not have any road at all, as it does not need one.

Construction of Plantation Road

In planning for road system in a plantation, care should be exercised in the economic aspects of its constructions and usage, ensuring at the same time, it gives maximum benefit. The main road is the most expensive one and must therefore be as short as possible. The others are constructed according to their suitability. As far as possible, roads passing through steep hills, ravines or swamps should be avoided. The steepness of the slope where a road is to be constructed should not exceed 1 in 30 or 2°. This is very critical, as most plantation roads only have gravel surfaces and therefore are easily eroded. All corners must be wide enough for maximum safety. On hilly terraced areas, roads must be made to cut as many terraces as possible to facilitate collection and transportation of crops such as latex. The width of plantation road should be 4-7 m and its total length per hectare is approximately 25 m for flat and 75 m for hilly areas.

Road surfaces must be strong enough to support vehicles running on them. Laterite soil or sand is used as dumpings for road surfaces, which must have a thickness of 15 cm after pressing and in two layers. If the roads are going to be frequently used by vehicles such as tankers, stronger dumping material, for example, granite must be used and they must be pressed several times to obtain even and smooth surfaces. Road surfaces must always be dry. Drains along both sides must be constructed at reasonable depth to channel off water from the road surfaces. There must also be outlets for the drained water. Road surfaces must be constructed cambered towards the centre at 1 in 30 or 2°, so that surface water can be quickly drained to the sides *(Figure 4.5)*. Laterite roads can easily be destroyed by water. In order to overcome this, bitumen is poured over them, in which case, the laterite layer below them should not contain more than 30% clay to avoid too much water being retained in the soil.

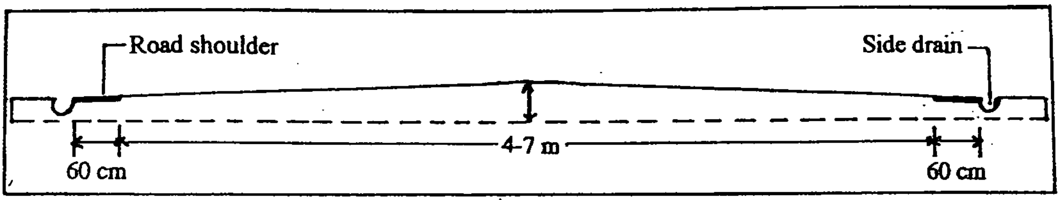


Figure 4.5 Cambered road surface

Road Maintenance

Roads must always have good surfaces. From time to time, they should be graded and pressed. This must be carried out when the surfaces are slightly moist. The cambered condition of road surfaces must always be maintained. Potholes in bitumen-surfaced roads must be patched up as they appear. The side drains must be regularly serviced.

RUBBER PLANTING DESIGN

Rubber planting requires a design or arrangement to portray rubber as a plantation crop. Well-arranged planted crops facilitate the task of locating and monitoring them when required, while at the same time they are pleasant to look at. A design is also required to determine whether the plantation is intended for other usage such as mixed or inter-croppings.

A planting design consists of three components - crop density, planting distance and purpose it is intended for. From studies previously carried out by the RRIM, 1 ha is suitable for planting 400-500 rubber trees. For the purpose of balancing tapping cost and yield, as in the estates sector, up to 400 trees can be planted, while in the smallholdings sector where tapping cost is of no importance, up to 500 trees per hectare can be planted. These trees are spread evenly over the 1 ha area, and by arranging them in a well-planned design, the above objectives can be achieved. Thus, planting distances can be designed to provide such densities. There are several to choose from, and each depends on its purpose. Whatever the design chosen, the rule is that the distance between trees should not be closer than 2 m, except for experimental purposes. *Table 4.7* provides several planting designs with various planting distances to achieve a density of 400-500 per hectare and a summary of their purposes.

However, it should be noted that, for the hilly areas, only avenue-shaped design is recommended. This is because, on hilly areas terracing is required, and where possible, such heavy work operations should be kept to the minimum. Again, as trees grow bigger and taller, closer inter-rows may cause over-crowded conditions for trees in the lower and upper terraces.

If the planting distances are known, planting densities per hectare can be calculated by using the formula shown overleaf.

TABLE 4.7 RUBBER PLANTING DESIGN

Design	Inter-row distance (m)	Inter-tree distance (m)	Area per tree (m^2)	Density per hectare	Remaks
Square	4.50 4.75 5.00	4.50 4.25 4.00	20.25 20.19 20.00	494 495 500	• Regular crown development and well-balanced crown • Early shading of the ground surface, thus early suppression of weeds • Longer planting point distance - more maintenance of planting row and longer walking distance during tapping • Early shading , thus shortened period for inter-cropping
Rectangular	5.25 5.75 6.25 6.75	3.75 3.50 3.25 3.00	19.69 20.13 20.31 20.25	509 497 492 494	• Shorter planting rows - thus less maintenance of planting rows and shorter walking distance during tapping • Late shading of ground surface, thus longer period for inter-cropping • Late shading of ground surface, thus late suppression of weeds • Irregular crown development resulting in less balanced crown
Avenue	7.25 8.00 8.75	2.75 2.50 2.25	19.94 20.00 19.69	502 500 508	• Shorter planting rows - less maintenance of planting rows and shorter walking distance during tapping • Later shading of ground surface, thus longer period for inter-cropping • Irregular crown development, resulting in less balance crown
Hedge	9.00 10.00	2.25 2.00	20.25 20.00	494 500	• Later shading of ground surface, thus late suppression of weeds • Very short planting rows, thus less maintenance of planting rows and shorter walking distance during tapping • Very irregular crown development resulting in imbalanced crown* • Very late shading of ground surface, thus longer period for inter -cropping • Also suitable for mixed cropping with other perennial crops
Double Hedge	25	2.00**	6.32	400	• Further reduction in rubber planting row distance thus further reduction in its maintenance of the rubber rows • Specially designed for mixed cropping with other perennial crops

TABLE 4.7 RUBBER PLANTING DESIGN (Contd.)

Design	Inter-row distance (m)	Inter-tree distance (m)	Area per tree (m^2)	Density per hectare	Remaks
Triangular or Quincunx	4.2	4.85	20.37	491	• Very regular crown development, resulting in very-well-balanced crown • Very early shading of ground surface, thus very early suppression of weeds • Longer planting rows, thus more maintenance of planting rows and longer walking distance during tapping • There is maximum utilisation of land in this design

* If low height short term inter-crops are practised

** Distance between trees in the triangle

- **For square, rectangular, avenue and single-hedge planting design:**

$$\text{Planting Density} = \frac{\text{Area per hectare } (m^2)}{\text{Area per tree } (m^2)}$$

Area per hectare	=	10, 000 m^2
Area per tree	=	Row distance x tree distance

Example:

Distance between planting rows	=	5 m		
Distance between trees	=	4 m		
Area per tree	=	5 x 4	=	20 m^2
Density per hectare	=	$\frac{10{,}000\ m^2}{20\ m^2}$	=	500 trees

- ***For double-hedge planting design***:

$$\text{Planting Density} = \frac{\text{Area per hectare } (m^2)}{\text{Area per tree } (m^2)} \times 2$$

Area per hectare	=	10,000 m^2
Area per tree	=	Row distance x tree distance

Example:

Distance between planting rows	=	25 m		
Distance between trees	=	2 m		
Area per tree	=	25 m x 2 m	=	50 m^2
Planting density per hectare	=	$\frac{10{,}000\ m^2}{50\ m^2} \times 2$	=	400 trees

- ***For triple-hedge planting design:***

$$\text{Planting Density} = \frac{\text{Area per hectare } (m^2)}{\text{Area per tree } (m^2)} \times 3$$

Area per hectare	=	10, 000 m^2
Area per tree	=	Row distance x tree distance

Example:

Distance between planting rows	=	31 m		
Distance between trees	=	2 m		
Area per tree	=	31 m x 2 m	=	62 m^2
Planting density per hectare	=	$\frac{10{,}000\ m^2}{62\ m^2} \times 3$	=	484 trees

- ***For triangular or quincunx planting design:***

$$\text{Planting Density} = \frac{\text{Area per hectare (m}^2\text{)}}{\text{Area per tree (m}^2\text{)}}$$

Area per hectare = $10{,}000\ m^2$

Area per tree = Row distance x tree distance x 0.866

Example:

Distance between trees in the triangle = 5 m

Distance between planting rows = 5 m x 0.866 = 4.33 m

Area per tree = 5 m x 4.33 m = $21.65\ m^2$

Planting density per hectare = $\frac{10{,}000\ m^2}{21.65\ m^2}$ = 462 trees

FIELD LINING

Lining is fixing of points in the field where planting is to be carried out. There are two types of lining - straight lining for flat areas and contour lining for hilly areas. Details of these are given in the following:

Straight Lining

Before lining work is carried out, lining equipment must be prepared. They are guide poles, planting pegs, lining ropes, a 30-m measuring tape and a prismatic compass. A straight lining can be of square, rectangular or triangular design.

Square and rectangular design. Assume that ABCD *(Figure 4.6)* is the area to be lined with a planting distance of 5 m x 4 m to obtain a density of 500 points per hectare. The longest straight boundary (AB) is used as the base line where guide poles are fixed at 5 m intervals. At both ends of the base line (*i.e.* E & F) right angles are marked using the prismatic compass or the measuring tape. The adjacent arms of the rectangle are extended towards CD using the lining ropes. At the same time planting pegs are fixed at each marking along the ropes. Another rectangular-shaped area is almost created within ABCD. Its fourth side GH can be obtained by measurements along the lining ropes. Guide poles are also fixed at 5 m along GH. A lining rope is then stretched across to meet the corresponding guide poles along EF and GH. Planting pegs are fixed at markings along the lining rope. The lining rope is then shifted to the next corresponding guide poles and the same procedure is repeated. This is continued until the whole of EFGH has been lined and pegged. Areas outside EFGH are also lined and pegged by extending the lines already made from EFGH. When completed, all the guide poles are removed and replaced with planting pegs *(Figure 4.6)*.

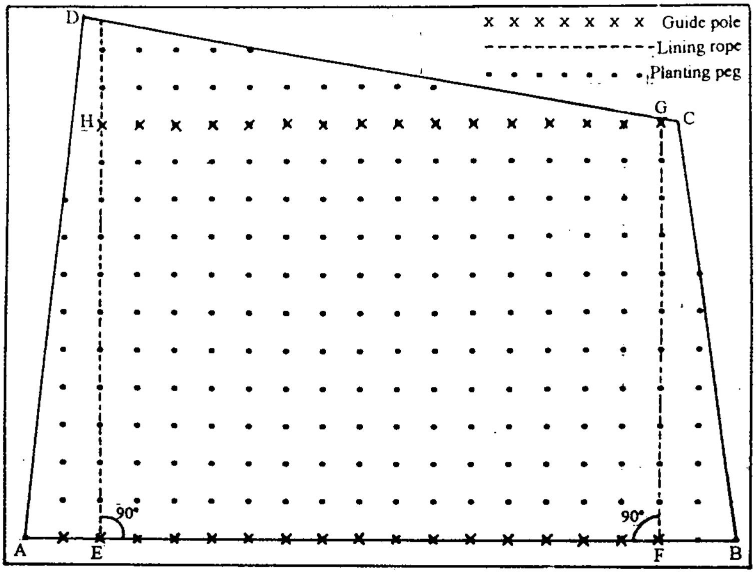


Figure 4.6 Square planting design

Triangular or quincunx. Assume that ABCD *(Figure 4.7)* is the area to be lined with a planting distance of 4.8 m x 4.16 m (which is the perpendicular height of the triangle) to obtain a density of 500 points per hectare. Again, the longest straight boundary (AB) is used as the base line, where guide poles are fixed at intervals of 4.8 metres. At suitable both ends of the base line (A and E), 60° angles are marked using the prismatic compass or the measuring tape. The arms of these angles are then extended towards CD using the lining ropes. At the same time, planting pegs are fixed at each marking along the lining ropes. A parallelogram-shaped area is almost formed within ABCD and its fourth side or boundary (FC) can be obtained from the measurements marked along the lining ropes. A lining rope is then stretched across to meet the corresponding guide poles along AE and FC. Planting pegs are fixed at markings along the lining rope. The lining rope is then shifted to the next corresponding guide poles and the same procedure is repeated. This is continued until the whole area (AECF) is lined and pegged. Areas outside AECF are also lined and pegged by extending the lines already made from AECF. When completed, all the guide poles are removed and replaced with planting pegs *(Figure 4.7)*.

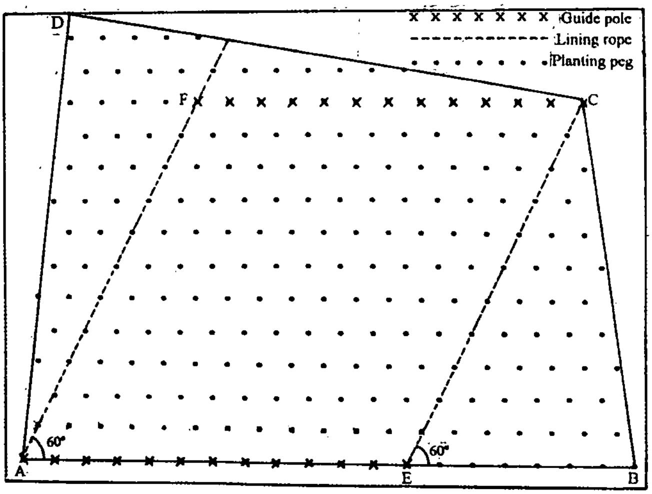


Figure 4.7 Triangular planting design

Contour Lining

Equipment such as guide poles, planting pegs, a 30-m measuring tape and a levelling instrument are used for contour lining. The planting distance to be used is 8 m x 2.5 m to obtain a density of 500 points per hectare. For contour lining of a hilly area, the base line is laid from the peak to the foot and where the slope is average, by fixing a guide pole, one at the top and another at the base, and stretching a string to meet the two points. The contour interval of 8 m is the horizontal (YX) and not the surface (ZX)distance *(Figure 4.8)*. It is therefore essential to determine first, the gradient of the slope where the base line has been laid. When the gradient is known, the surface distance between contours can be calculated by the mathematical cosine rule, in which the four-figure logarithmic table or equivalent has to be referred to.

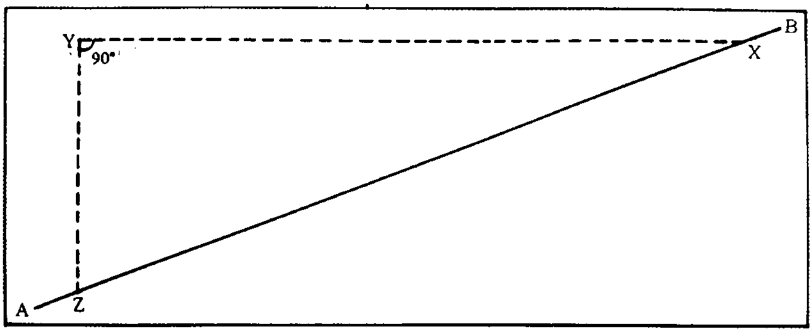


Figure 4.8 Determining the inter-contour distance on a hill slope

AB is the line of average slope (base line)

Assume that its gradient	=	1 in 2 (18°)
XY (the fixed horizontal distance	=	8 m

$$XZ \text{ (surface distance between contours)} = \frac{XY}{\text{Consine } X}$$

$$= \frac{8\text{ m}}{\text{Consine } 18^{\circ}}$$

$$= \frac{8\text{ m}}{0.9511}$$

$$= 8.41\text{ m}$$

Starting from the top, guide poles are then fixed at intervals of 8.4 m along the base line. Plotting the contour line is done from the top of the hill, starting at the second guide pole, using either the road tracer, Abney level, clinometer the hurdle-mounted spirit level or any other levelling instruments.

Road tracer method. The road tracer is placed upright at the guide pole with its telescope facing the side of the slope. The sighting board is placed in front of the telescope at a convenient distance, say, 10 m from the guide pole. Eyeing through the telescope, the centre point on the sighting board is located. When the centre points in the telescope and on the sighting board are aligned, both the road tracer and the sighting board are standing at points of the same level. A planting peg is fixed at the foot of the sighting board. If the two centre points are not aligned, the sighting board should be shifted either up or down hill until they are level. The road tracer is then moved to the planting peg which has just been fixed, followed by the sighting board 10 m in front of it, and the same procedure is repeated until a number of planting pegs are seen fixed in a line, each 10 m apart. This is known as a contour line, as it is not straight, following the curves and bulges of the slope. This line is continued until it meets the boundary of the area, or if the area is a full hill, the contour line should meet at the starting point, where the guide pole is fixed. When a contour line is completed, the road tracer is shifted to the next (lower) guide pole and the same procedure is repeated until the entire hill area is contour-lined and pegged. If at any part of the slope, the contour lines are closing up by less than half (less than 4.2 m) the distance between contour lines, the plotting is stopped. But when the contour line opens up or becomes wider at more than one and a half (more than 12.6 m), a contour line is filled in between them, and this is known as a blind contour. The guide poles are then removed and replaced with planting pegs *(Figure 4.9).*

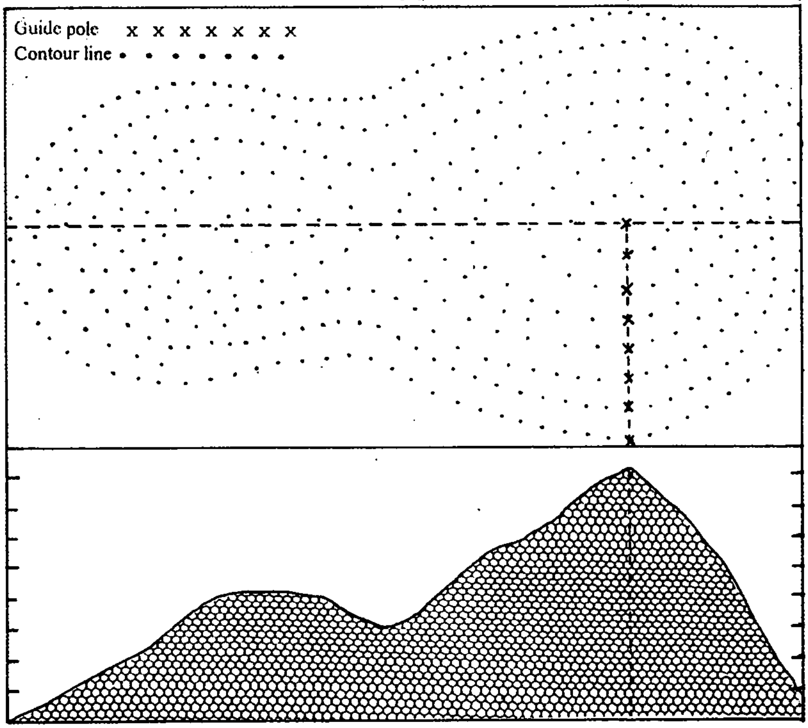
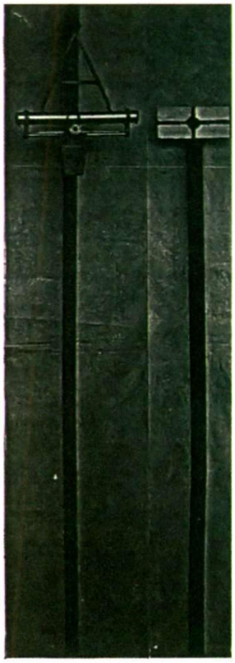


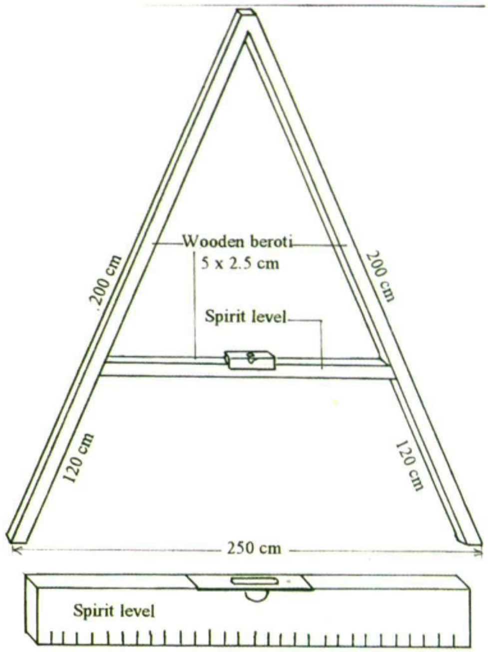
Figure 4.9 Contour lining a hilly area – a plan of the contoured hill (above) and cross-section of the same hill (below)

Hurdle-mounted spirit level method. One leg of the hurdle is placed at the guide pole and the other one is moved slightly up or down hill until the air space in the spirit level fluid is centred. This indicates that both the hurdle legs are standing at points of the same level. A planting peg is then fixed at the second leg. The hurdle is then shifted with one leg now at the planting peg and the other moved until a level is indicated by the instrument. Another planting peg is fixed at the third point of the same level. This procedure is continued until the contour line meets the boundary. If the area is the whole hill, the contour line should meet at the starting point. The hurdle is then shifted to the next (lower) guide pole and the above procedure is repeated until the entire area is contour-lined and pegged. A contour line is discontinued when it converges with the upper one at less than half (less than 4.2 m) the distance between contour lines. A blind contour line is filled in where the contour lines open up at more than one and a half (more than 12.6 m) the distance. All the guide poles are removed and replaced with planting pegs *(Figures 4.9)*

Guide poles can be made from straight rounded jungle poles of 3 cm in diameter and 2 m in length, and sharpened at the bottom end. Planting pegs are made from split bamboo stem of 1 cm in diameter and 1 m in length and sharpened at the bottom end. A lining rope is best made from rattan of 1 cm in diameter and 40-60 m in length. Planting points are marked along the lining rope. Other materials such as the manila rope and galvanised wire can also be used as lining ropes. The hurdle which is in the shape of the letter A (sometimes called the A-frame) is made from wooden beroties 5.0 cm x 2.5 cm and 2.0-2.5 m in length with a crossbar made from the same beroti and is fixed parallel to the ends of the hurdle legs. The distance between the leg ends follows the distance between planting points, in which case 2.5 metres. The spirit level is fixed at the centre of the crossbar *(Figure 4.10)*.



(a) Road tracer and sighting board



(b) Hurdle (A-frame) and spirit level

Figure 4.10 Contour lining equipment

PLANTING PERIMETER FENCING

A fence can be considered as an impediment; placed or laid along the boundary of a plantation. There are several types of plantation fencing, but the most common is the barbed wire fixed on posts.

Objectives of Plantation Perimeter Fencing

Erecting a perimeter fence along the plantation boundary has several objectives, and the main ones are to:

- demarcate the plantation boundary
- avoid any dispute with regards to land ownership
- keep away animal pests
- provide protection to planted crops
- ensure general security of the plantation

Method of Erecting Fence

Fences are usually erected after land clearing. All the boundary stones must first be located and clearly marked. A string is then stretched along the perimeter, meeting all boundry stones marked. Starting from one corner, points where fencing posts are to be planted are marked along the string at intervals of 2.5 metres. This ensures that the fence is straight and neat. The posts are made of hardwood timber such as resak of 7.5 cm x 5 cm x 210 cm in size or hardwood jungle rollers of 7.5 cm diameter and of 210 cm in length. The posts at all corners must be of similar type of wood, 7.5 cm x 7.5 cm x 210 cm in size. The posts are buried 60 cm deep. At every eighth post and at all corners, supports are erected with the same type of wood of 7.5 cm x 7.5 cm x 210 cm in size. The pair of posts where the gate is to be erected should also be of the same size as the corner posts. All fencing wires are fixed from the outside. Normally, four strands of barbed wire are used, the first one at ground level, the second, third and the fourth at 50 cm, 100 cm and 150 cm from the ground, respectively. The barbed wires must be pulled taut before nailing. To keep way small animals, wire netting of 3 cm mesh and 100 cm in width is fixed at the lower section of the fence. At a suitable point along the fence, a gate is constructed for easy access into the plantation.

PLANTING HOLE

The initial growth of crops in the field starts from the planting hole. Large and very well made planting holes are expected to assist in spearheading the initial growth of crops.

Objectives of Holing

Before any field transplanting of rubber is done, planting holes are prepared well ahead of time *(Figure 4.11)*. The objectives of holing are to:

- obtain a block of loose soil
- facilitate root development at a critical stage
- remove rocks and other hard materials which may be hidden in the soil
- remove root disease source, if any
- enable the weathering and seasoning of the planting hole
- facilitate application of basal fertiliser (rock phosphate)
- facilitate transplanting of rubber

(a) Manually-dug planting hole

(b) A mechanical digger (soil borer) is used at sloping areas

Figure 4.11 Preparing planting holes

Method of Holing

Planting holes are dug much earlier before planting to allow them to weather by sunlight and rain. Holes are dug at the planting pegs fixed during field lining, with the pegs used as the centre points of the planting holes. The soil dug out is placed as near to the brim of the holes as possible and in not more than two heaps. The top half and the bottom half of the soil from the hole should be separated. When completed, the planting pegs are fixed back into the centre of the holes. The minimum size of a planting hole is 60 cm x 60 cm x 60 cm. Sixty manually-dug planting holes can be completed in a day. But when speed is necessary, cylindrical planting holes of 45 cm diameter and 45 cm deep can be dug mechanically.

CHAPTER 5

RUBBER PLANTING AND MIXED CROPPING

PLANTING

After allowing the planting holes to weather for about two to three weeks, transplanting activities can be carried out. Current technology requires the use of polybag buddings, either budded stumps in polybags, young buddings in polybags or the more advance-aged core stumps prepared in the nursery, as planting materials.

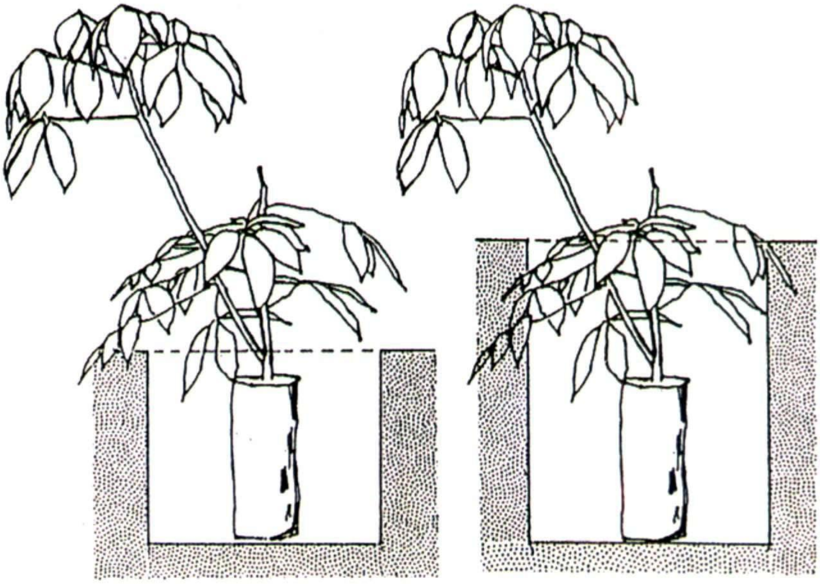
Objectives of Planting

Other than developing a plantation of rubber crops, proper planting technique helps to:

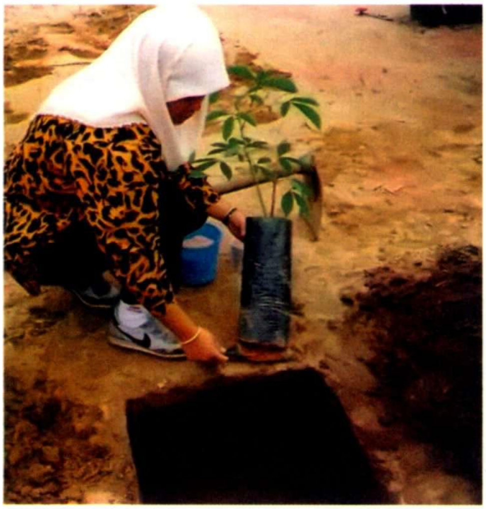
- initiate crop growth
- achieve a high percentage of planting success
- reduce replacement
- maximise the use of potentially good planting materials
- reduce plantation development cost

Method of Planting

A polybag budding is normally planted up to the base of the scion shoot or stem. It can also be planted much deeper, until one whorl of the scion is buried, which in normal growth, is up to 15 cm of the scion stem. This is known as deep planting. First, the polybag is placed upright in the planting hole to determine the correct depth. If it is not deep enough, it should be deepened and if it is too deep, it can be refilled to the required depth. The bottom of the polybag is cut away to expose the soil. The polybag is again placed upright in the centre of the hole. A vertical cut is made on the side of the polybag. The hole is refilled with the top half of the soil first. The cut polybag is then carefully pulled out. The hole is completely refilled with the rest of the soil after mixing it with 113 g rock phosphate. Only the soil around the brim of the hole is pressed to avoid damaging the roots. Mulching is then applied around the plant *(Figure 5.1)*

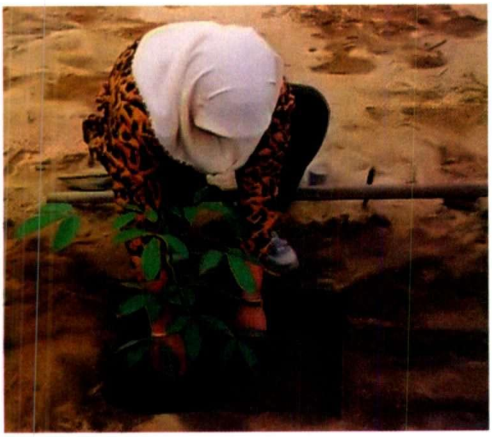


(a) Diagram showing depth of planting – normal (left) and deep (right)



(b) Cutting away polybag bottom and partly the side

(c) Placing polybag in the planting hole



(d) Refilling hole partly and removing the polybag

(e) Refilling hole completely with soil plus rock phosphate

(f) Press soil around the brim of the hole

(g) Planting completed

Figure 5.1 Planting polybag material

From experiments carried out, deep planting technique described earlier helps in the growth of rubber plants. *Tables 5.1* and *5.2* show the effect of deep planting on growth rate of PB 255.

TABLE 5.1 EFFECT OF DEEP PLANTING ON GROWTH OF YOUNG BUDDINGS OF PB 255

Depth of planting (cm)	Girth (cm)	
	12 months	18 months
0	9.0	12.2
15	10.5	13.8

TABLE 5.2 EFFECT OF DEEP PLANTING ON GROWTH OF YOUNG BUDDINGS OF PB 255

Depth of planting (cm)	Girth (cm)		
	12 months	18 months	21 months
5	4.7	8.3	11.2
15	5.0	9.4	12.1

In deep planting technique, covering of the green scion tissue with sandy soil type may cause scorching of the green bark. Therefore, a cavity should be left around the plant during planting, and allowed to be refilled by itself over time.

To achieve good and healthy growth of plants, ensure that only good quality planting materials are transplanted into the field. The following are some guidelines:

- Plants are healthy
- Stem girths are of the same size
- Plants have at least two whorls of hardened leaves
- Plants are free from leaf diseases
- Polybags are not broken, the soil cores are still intact

When transplanting rubber into the field, it is advisable to plant out 10% extra materials, which can later be used as replacement. These can be planted along the normal planting strips after every tenth planting point in a density of 500 point per hectare. Alternatively, they can also be planted in the inter-rows.

MULCHING

Mulching can be defined as providing (not by growing) cover to the soil surface, especially around the base of crops with whatever type of green litter and other materials. Mulching is recommended particularly on transplanted rubber crops. It is an old established farm practice, but its importance was only realised in recent years.

Advantages of Mulching

Several advantages can be obtained by applying this farm practice, and the important ones are that, it:

- Protects Soil Surface From Direct Sunlight
- Preserves Moisture In The Soil
- Encourages Feeder Root Development In The Top Soil (*Table 5.3*)
- Prevents Weed Growth
- Reduces Soil Erosion
- Improves Soil Structure
- Adds Organic Matter To The Soil
- Enhances Growth Of Rubber Crops (*Table 5.4*)

TABLE 5.3 EFFECT OF MULCHING ON FEEDER ROOT DEVELOPMENT AND GROWTH OF MAXI STUMPED BUDDING CLONE RRIM 600

Treatment	Weight of feeder root within 0-15 cm of soil	Girth increment at 16-18 months (cm)
No mulching	0.23 g/1000 cc of soil	7.2
With mulching	1.02 g/1000 cc of soil	9.0

TABLE 5.4 EFFECT OF VARIOUS TYPES OF MULCH ON GROWTH OF RRIM 600

Type of mulch	Girth increment (cm) (After 13 months)
Control (no mulch)	6.6
Oil palm kernel	7.3
Oil palm fruit bunch	7.1
Imperata cylindrica	7.1
Coconut husk	6.7

Mulching Materials

The following are some of the categories of material that can be used for mulching:

- Plant litter such as *Imperata cylindrica* (lalang), empty palm fruit bunches, fruit skins, coconut husks, palm kernel.
- Used packing materials such as fertiliser bags, cement bags, sugar bags and other polythene or paper wrappings.

Usually such materials are regarded as worthless and often go into the rubbish dump or worse still, burnt. But they are assets to agriculture.

Method of Mulching

Mulching is recommended immediately after transplanting of rubber planting materials into the field. The mulching material is spread around the base of the crop to cover the soil at a radius of 30-60 cm with a thickness of five centimetres. A space of five cm should be left vacant around the plant base to avoid fungal growth. If packing materials are used, weights should be placed at the corners to prevent being rolled up or blown away by wind. If paper bags are used they should be in four or five layers (*Figure 5.2*).

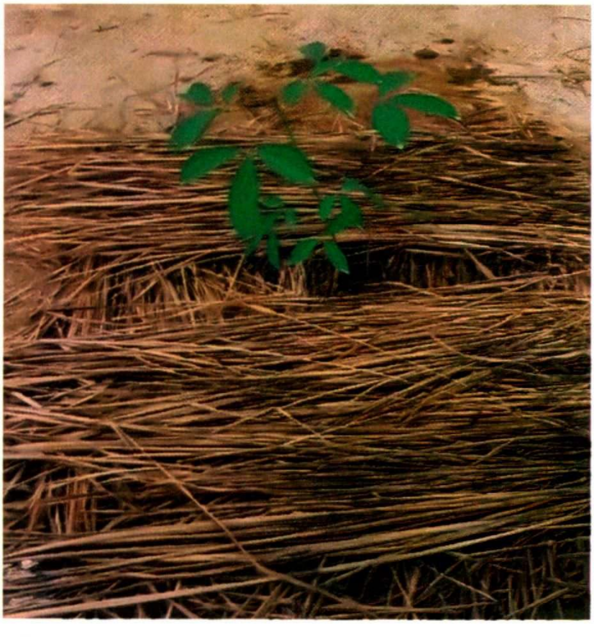


Figure 5.2 Lalang grass (*Imperata cylindrica*) used as mulching material

MIXED CROPPING

Mixed cropping under rubber is planting of rubber with other cash crops in the same area. It has been practised in a number of rubber-producing countries since 1930. In Malaysia, mixed cropping was said to have started during the Japanese Occupation (1942-1945) where the planters were forced to replace rubber with food crops to overcome shortage of food supply. However, some planters did not cut down the rubber trees, instead planted food crops in the inter-rows of rubber *(Figure 5.3).* This was the beginning of the practice of mixed cropping under rubber gradually diminished. Subsequently, however, low rubber prices encouraged rubber smallhoders to practise mixed cropping in their rubber holdings. This also enables them to obtain supplementary income, especially during the immature stage of rubber.

Objectives of Mixed Cropping

Mixed cropping of rubber with other crops has the following objectives, and they are to:

- achieve maximum utilisation of limited land
- diversify crops within a limited area
- increase income from a limited area
- avoid dependence of income from a single crop

(a) Rubber + sugarcane + papaya

(b) Rubber + maize

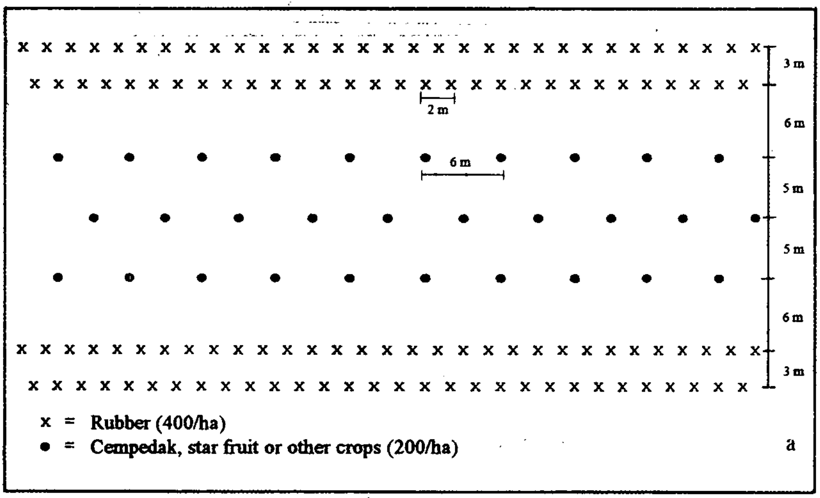
(c) Rubber + pasture + sheep

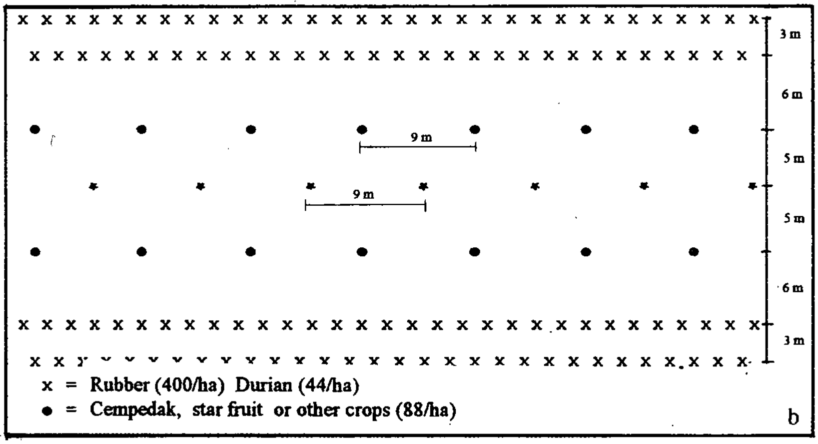
Figure 5.3 Various types of mixed cropping

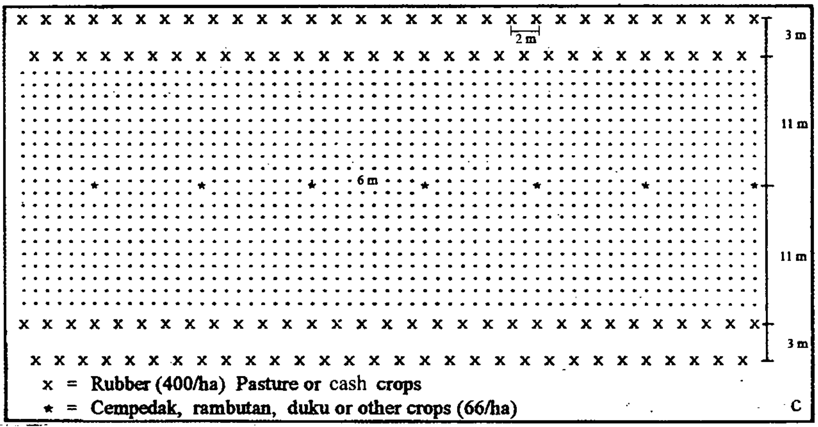
Method of Mixed Cropping

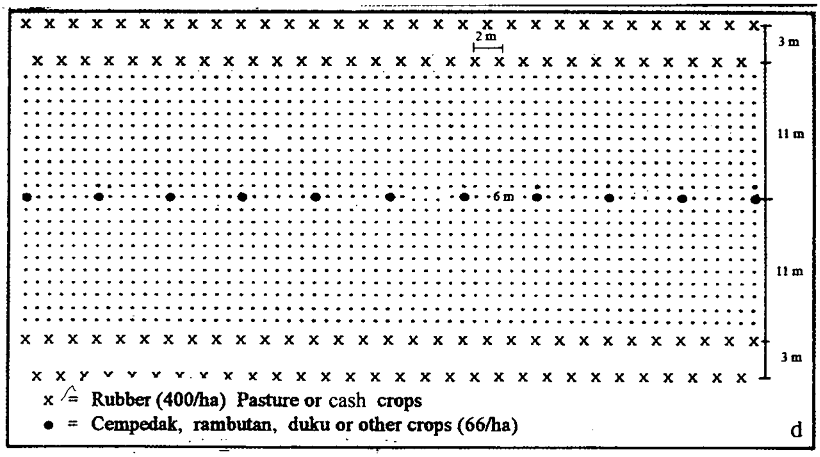
In mixed cropping, rubber as the main crop is planted with other cash crops with a density of about 400 trees per hectare. To enable other crops to survive, the planting design is of three types, namely, single hedge, double hedge or triple hedge system. In such designs, the inter-row distances of rubber are very wide, while the inter-tree distances are very close. In the double and triple hedge designs, the inter-tree distances are not only close but the trees are arranged in triangular formation, with double and triple rows. In the wider inter-row spaces, other perennial crops are planted.

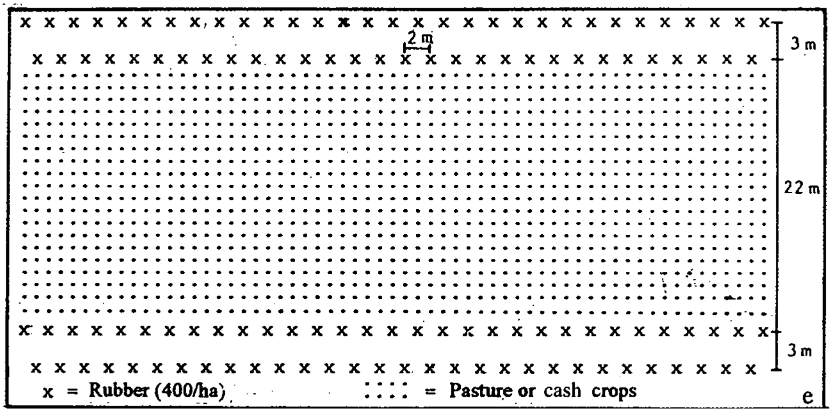
Since the rubber trees are planted very close in the row, the irregular crown development may cause lopsided effect as the trees grow older. To avoid this, only clones suitable for close planting (less than three metres) such as RRIM 728, RRIM 729, RRIM 805, RRIM 901, RRIM 905, RRIM 936, RRIM 937, RRIM 938, PB 217, PB 260, PB 254, PB 255, BPM 24 and Nab 17 are recommended. Suggested perennial crops to be planted are durian, cempedak, mango, rambutan, duku and cocoa. Short-term crops and pastures can also be included. However, the suitability of the crop chosen must first be determined before venturing into this system of planting. The local agricultural extension agents should be able to assist in this matter. *Figure 5.4* shows suggested planting designs of various crop mixtures that can be cultivated with rubber.

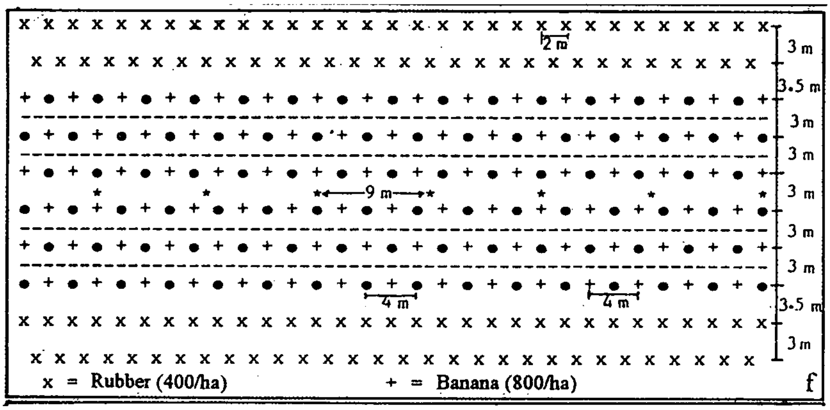


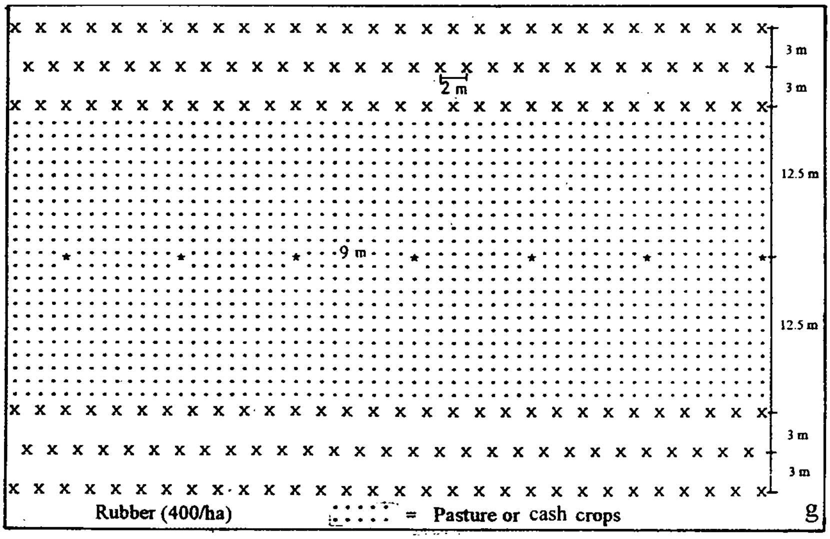

3 m
6 m
9 m
5 m
9 m
5 m
6 m
3 m
x = Rubber (400/ha) Durian (44/ha)
• = Cempedak, star fruit or other crops (88/ha)
b


2 m
3 m
11 m
6 m
11 m
3 m
x = Rubber (400/ha) Pasture or cash crops
* = Cempedak, rambutan, duku or other crops (66/ha)
c


2 m
3 m
11 m
6 m
11 m
3 m
x = Rubber (400/ha) Pasture or cash crops
• = Cempedak, rambutan, duku or other crops (66/ha)
d


2 m
3 m
22 m
3 m
x = Rubber (400/ha)
= Pasture or cash crops
e


2 m
3 m
3.5 m
3 m
3 m
9 m
3 m
3 m
3 m
4 m
4 m
3.5 m
3 m
x = Rubber (400/ha)
+ = Banana (800/ha)
f


2 m
3 m
3 m
12.5 m
9 m
12.5 m
3 m
3 m
Rubber (400/ha)
= Pasture or cash crops
g

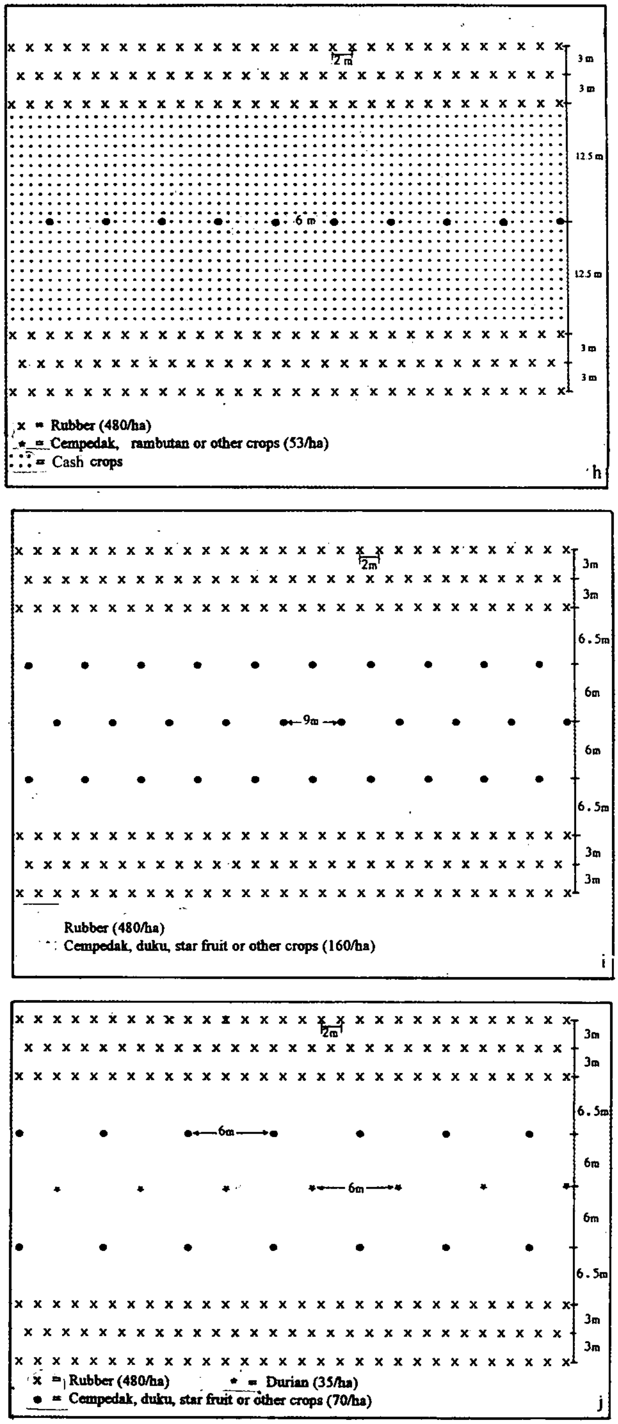


Figure 5.4 Various mixed crop planting designs

(a) Single rubber row with fruit trees on terrace

(b) Two rubber rows with fruit trees on undulating ground

(c) Three rows of rubber trees with fruit trees planted in the inter-cropping area at 25 m distance

Figure 5.5 Different types of hedge planting

POINT PLAN

A point plan can be defined as a plan of the plantation area showing its topography, planting rows, terraces, crop points, buildings and infrastructure such as roads, paths, rivers, streams, bridges and culverts. A point plan is an aerial view of the plantation.

Objectives of Point Plan

The objectives of having a point plan of a plantation are to:

- have a good knowledge of the general condition of a plantation
- know the location of the plantation including the planted crop, buildings and infrastructure without going to the field
- utilise it as office record
- facilitate field maintenance work such as manuring, weed control and others
- facilitate monitoring of field operations
- facilitate the allocation of tapping tasks when the trees reach maturity
- facilitate plantation planning and budgeting
- assist in research and development activities

Drawing-up a Point Plan

To draw up a point plan of plantation, a topography map of the area must first be obtained from the Survey and Mapping Department. Two boundary plans of the plantation are drawn on graph papers. To facilitate this, one has to refer to the plan illustrated in the title grant. The topography of the plantation is marked out on the plan. This can be copied from the topography map. Then go to the field and mark out roughly on the plan the locations of the planting rows, terraces, trees or plants, buildings and all the infrastructure. The exact measurements of the above must be taken. Transfer all the recordings made in the field on to the spare plan with their exact measurements. In addition, it is also useful to show the neighbouring land conditions, even if they do not belong to the same owner, and other nearby landmarks. It is also important to indicate the north sign. Recordings on the plan should be made with signs and symbols to save space, with their explanations given at one corner of the plan sheet. Some examples of suggested signs are given in *Table 5.5*.

TABLE 5.5 SUGGESTED SIGNS FOR POINT PLAN RECORDINGS

Content of plantation	Suggested sign
Topography	Colour shading
Public road	Bold black line
Plantation road	Ordinary black lines
River/stream	Ordinary double lines
Bridge/culvert	Double brackets facing outwards
Building	Diagram of building
Planting point (straight)	Equidistant dots in a straight line
Planting point (terrace)	Equidistant dots along a contour line
North	Arrow pointing north

Note: Any sign or symbol can be used as long as the explanation is provided

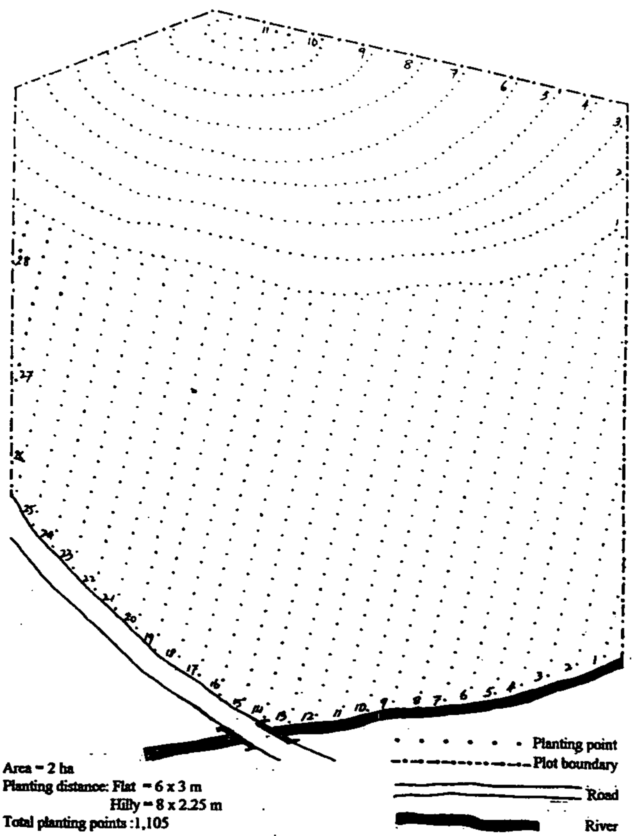


Figure 5.6 A sample point plan of a rubber plot

For a large area, the making of a point plan is difficult as it requires a large sheet and drawing board. This can be overcome by breaking-up the area into several blocks. The criteria for demarcating the blocks can be rivers, streams, roads or hills. The point plan can then be made block by block. All entries made must be checked for accuracy by going back to the field, and alterations made where necessary. Again back on the drawing board, the point plan is copied on to a tracing paper. The point plan can be completed by additional information such as hectarage, date of planting, clones used, planting distances, densities and so on. If the point plan has been divided by blocks during preparation (due to its large size), the separated sheets can be joined to form a single point plan for the whole plantation. A sample point plan is given in *Figure 5.6*.

CHAPTER 6

FERTILISER APPLICATION AND FIELD MAINTENANCE

All plants including rubber require adequate amount of water, light, carbon dioxide and nutrients for growth to their maximum potential. A shortage or an excess of one or more of these elements, the presence of disease or extreme climatic conditions cause reduction in growth, yield and the quality of the crop produce. Water, light, and carbon dioxide are naturally available, however, nutrients are added by fertiliser application.

FERTILISER AND ITS FUNCTION

Fertiliser is defined as a substance that provides nutrients to plants for their growth to enable it to function well. Plants like rubber respond favourably in terms of growth and yield to adequate and proper fertiliser application. Among the elements, the major ones are nitrogen (N), phosporus (P), potasium (K) and magnesium (Mg).

N is essential for the formation of plant tissue, plant protein and chlorophylll. P is necessary for nucleic acid structure, phospholipids, assimilation and respiration of plants. K is required for assimilation of protein, carbohydrate as well as lipid, while Mg is necessary for chlorophylll development. Other elements needed in micro quantity are sulphur (S), calcium (Ca), iron (Fe), manganese (Mn), molybdenum (Mo), copper (Cu), boron (B), zinc (Zn), nickel (Ni) and chlorine (Cl).

TABLE 6.1. EFFECT OF FERTILISER ON GROWTH OF TWENTY SEVEN MONTHS OLD RUBBER

Treatment	Girth (cm)
No fertiliser	18.2
With NPKMg fertiliser	23.2

TABLE 6.2. EFFECT OF NITROGEN ON YOUNG RUBBER ON SELANGOR SERIES SOIL

Treatment	Girth (cm)	
	Trial 1	Trial 2
Ammonium sulpate	52.95	45.13
Urea	53.58	44.57
SE (±)	0.591	0.913
P< 0.05	1.79	2.17

TABLE 6.3 EFFECT OF PHOSPHORUS ON GROWTH OF RUBBER

Treatment	Girth (cm)
Without phosphorus	48.4
With phosphorus	52.4

TABLE 6.4 EFFECT OF UREA ON GIRTHING RATE OF RUBBER AT 160 CM HEIGHT

Treatment	Year 1	Year 2	Year 3	Year 4
N1 F1	14.2	28.4	40.2	49.1
N1 F2	14.0	28.3	40.3	50.3
N1 F3	14.7	29.4	41.4	50.4
N2 F1	15.2	29.9	42.5	52.2
N2 F2	11.3	24.7	36.8	45.4
N2 F3	14.2	28.1	40.3	50.2
Mean	13.9	28.1	40.3	49.6
Control	10.9	23.5	35.5	46.0

Note:

N1	UREA
N2	Mix
Control	None

F1	1X
F2	2X
F3	4X

TABLE 6.5 EFFECT OF DIFFERENT SOURCES OF PHOSPHATE ON GIRTHING RATE OF RUBBER AT 160 CM HEIGHT

Treatment	Year 2	Year 3	Year 4	Year 5	Year 6	Increment
Control	17.7	27.8	34.0	39.1	44.3	26.6
CIRP	19.6	30.0	36.7	41.9	44.9	25.3
CHINA	18.5	28.3	34.8	38.4	42.9	24.4
GAFSA	18.8	28.7	35.2	40.0	43.5	24.7
Mean	*18.7*	*28.7*	*35.2*	*39.9*	*43.9*	25.25

* Fertiliser applied as Mix Mag X and Mag Y after 36 month

TABLE 6.6 EFFECT OF FERTILISER ON BARK RENEWAL

Treatment	Bark thickness at third year (mm)
Without phosphorus	5.2
With phosphorus	5.3
Without potassium	5.1
With potassium	5.4

In general,adequate and proper fertiliser application will:

- encourage good growth in favour of early tapping
- increase latex production and wood volume
- provide early canopy closure that grants shade and retards undergrowth thereby reduces cost of weeding
- promote good renewed bark
- provide protection against diseases

Optimum Use of Fertiliser

The optimum use of fertiliser can be defined as an approach whereby the right quantity of fertiliser application to plants that ensures positive economic impact to the farmer and minimum loss of nutrients to the environment.

Factors that should be considered into before fertiliser application is carried out are:

Type of soil – Soil is classified according to physical and chemical characteristics. Physical characteristics consists of soil structure (*e.g.* soil aggregate), soil texture (*e.g.* sandy, clayey), moisture and soil aeration. Soil chemistry includes soil nutrients, pH, organic matter content and cation exchange capacity. Knowledge on soils help in proper fertiliser application management as different class of soil responds differently to fertilisers.

Type of fertilisers – There are three types of fertilisers namely straight, mixture and compound. Straight fertilisers provide one type of nutrient while mixture and compound fertilisers provide two or more nutrients. Compound fertilisers are better as they are uniform in the ratio of elements required. Both mixture and compound fertilisers can be used for rubber if the ratio of N, P, K and other elements are appropriately prepared for rubber trees.

Rate and amount of fertiliser - For good response, the rate of fertiliser application should be in accordance to the amount and type of fertiliser recommended. The recommended rate and amount of fertiliser for young rubber is given in *Table 6.11.*

Zone of fertiliser application - Fertilisers should be applied to the feeder root zone for maximum uptake of nutrients. For young and small trees, fertiliser application is confined to the small circle area under the canopy while for mature trees; fertiliser is applied between the rows or inter-row (*Figure 6.5).*

Depth of fertiliser application – Fertilisers can be applied by broadcasting, or incorporated with soil depending on suitability. Loss of fertiliser by erosion or volatilisation can be reduced if fertiliser is incorporated with the soil (*Figure 6.2*).

For mature trees, Discriminitory Fertiliser Recommendation is recommended based on the following:

- nutrient status of the trees and soil
- results from experiments
- additional information such as history of fertiliser application, clone, yield and wind damage susceptibility
- recommendation is for a period of two years

Time of fertiliser application - The uptake of nitrogen by rubber trees is most active at the commencement of refoliation up to five months thereafter. Rate of uptake is positively correlated with the emergence of new leaves.

Fertiliser is recommended to be applied after refoliation. In general, one kg/tree of fertiliser need to be applied. It is advised to split the application whereby the second application should be before June. For sandy areas, it is advised that fertiliser is applied as split applications twice or more in Feb/Mar and May/June.

In area where clones are susceptible to wind damage, reduced canopy is required to avoid trunk snap.

- Amount of fertiliser need to be adjusted in wind damage prone areas. Rate of nitrogen should be reduced
- Fertiliser application is carried out during wintering
- If the risk of wind damage is high, avoid fertiliser application during wintering but to be applied before June

- Reduce the amount of fertiliser to half of the recommendation. This is because there is less uptake of nutrients for a period of three to four months after refoliation.

Fertiliser Application for Stimulated Trees

For trees that have been stimulated either using ethephon or ethylene gas, extra fertiliser is needed to compensate the loss of nutrients owing to increase in latex production.

For every 1,000 kg/ha of dry rubber, 11 kg of N and 12 kg of K_2O is needed. This is equivalent to 55 kg of Ammonium Sulphate and 25 kg of Muriate of Potash for every hectare of rubber.

Nutrients

All living plants need nutrients which are available in fertilisers. Plant nutrients can be divided into three groups (*Table 6.7*).

TABLE 6.7 PLANT NUTRIENTS

Group	Classification	Nutrients
A	Essential	Carbon Hydrogen Oxygen
B	Major	Nitrogen Phosphorus Potassium Magnesium Calcium Sulphur
C	Minor or trace	Manganese Copper Boron Iron Zinc Molybdenum Chlorine

The total number of nutrients required by plants is sixteen. Plants obtain nutrients of elements in group A from the air and water, and are usually sufficient, except when large fires or long droughts occur. They are classified as essential because no plant can exist without them. Nutrients in group B are known as major nutrients or elements as they are required by plants in large quantities, and are supplied through fertilisers. Nutrients in group C are also required by plants, though in small quantities. Plants usually exhibit nutrient deficiency on the leaves. Analysis of the leaves and soil can confirm this. In fact manuring of planted crops based on such analysis is most effective. This is known as discriminatory fertiliser application.

Functions of Major Nutrients

Nitrogen is very important for plant growth as it is a constituent of a proteins, protoplasm and chlorophyll, thus it helps in left development are thereafter photosynthesis. Phosphorus is important in plant cell divison and the development of meristematic tissues, thus it assists in root development.

Potassium plays an important part in plant metabolism and in the overall growth of plants. Magnesium is important in photosynthesis as it is a constituent of chlorophyll. Calcium is also a constituent of the cell, that is the middle lamella and also important in root development. Sulphur is also a constituent of all proteins and it is also associated with the formation of chlorophyll, although not its constituent.

Nutrient Deficiency

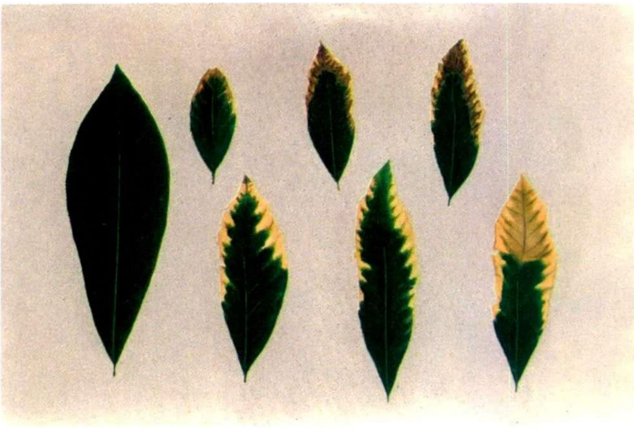
Usually, a plant deficient of nutrient exhibits its symptoms on the leaves. Insufficient nitrogen is indicated by the pale green and later total yellow. Phosphorus deficiency, is characterised by the underside of the leaf becoming brown in colour beginning from the tip. When the leaf margin becomes yellow, it shows that the plant is deficient in potassium. When the spaces between the leaf veins turn pale yellow in colour and the veins look like herring bones. When the leaf tip and leaf margin appear scorched turning white to brown in colour, calcium deficiency is indicated. Deficiency in sulphur, which is quite common in young leaves, results in the leaf becoming pale green and smaller in size, and after something necrosis of the leaf tip and margin occurs (*Figure 6.1*).

(a) Nitrogen deficiency

(b) Phosphorus deficiency

(c) Potassium deficiency

(d) Magnesium deficiency



(e) Calcium deficiency

(f) Sulphur deficiency

Figure 6.1 Major nutrient deficiency symptoms in rubber leaves (first leaf from the left is not deficient)

Types of Fertilisers

Fertilisers can be grouped into two – organic and inorgnic. Organic or natural fertilisers originate from plant and animal organs including their excretions. When they decompose they become fertilisers to the living plants. Inorganic fertilisers are synthesised by chemical process, and are available in three forms, namely, straight, mixture and compound fertilisers. Details concerning them are given in the following text.

Straight (single) fertilisers. When a plant is deficient in a particular nutrient a straight fertiliser containing that particular nutrient is applied to the plant to rectify the problem. Generally, straight fertilisers contain only one nutrient, there are some containing one major nutrient with one or two minor ones. Examples of some straight fertilisers are found in *Table 6.8.*

TABLE 6.8 EXAMPLES OF STRAIGHT FERTILISERS

Fertiliser	Form	Nutrient content (%)				
		N	P_2O_5	K_2O	CaO	MgO
Ammonium sulphate	Crystal	21				
Ammonium nitrate	Crystal	35				
Ammonium chloride	Crystal	26				
Calcium ammonium nitrate	Crystal	21				
Calcium cynamide	Powder	21				
Sodium nitrate	Crystal	16				
Nitro 26	Granule	26				
Urea	Crystal	45				
CIRP	Powder	-	36	-	50	-
FRP	Powder	-	36	-	42	-
NARP	Powder	-	27	-	42	-
Single superphosphate	Crystal	-	16-18	-	-	-
Double/triple superphosphate	Crystal	-	46	-	10	-
Ammonium phosphate	Crystal	11	48	-	-	-
Diammonium phosphate	Crystal	21	53	-	-	-
Basic slag	Various	-	18-19	-	-	-
Potassium chloride (Muriate of potash)	Crystal	-	-	61	-	-
Potassium sulphate (Sulphate of potash)	Crystal	-	-	50	-	-
Potassium magnesium sulphate	Crystal	-	-	29	-	9
Magnesium sulphate (Kieserite)	Crystal	-	-	-	-	26
Magnesium limestone (Dolomite)	Powder	-	-	-	30-35	20
Calcium carbonate	Powder	-	-	-	54-56	-

There are mainly two forms of straight fertilisers, namely, crystals and powders. The crystal form of fertilisers are easily soluble in water, and quickly absorbed by the roots. However, under tropical conditions, it is highly volatile or easily leached. Fertilisers in the form of powders are not readily soluble and take much longer time to be absorbed by the roots, but are not volatile and can provide cumulative effect to the soil.

Mixture fertilisers. Mixture fertilisers are made up of more than one straight fertilisers mixed together by physical means. Usually, mixture fertilisers contain only nitrogen, phosphorus, potasium and magnesium (NPKMg). Other special formulations can also be produced on request, as they can be easily prepared by simple physical mixing. RRIM mixtures are rock phosphate-based and formulated specially for use on rubber (*Table 6.9*), while the Nutrex mixtures are soluble phosphate-based.

TABLE 6.9 RRIM-FORMULATED MIXTURE FERTILISERS

Type	Formulation (% nutrient)			
	Ammonium Sulphate (N)	CIRP (P_2O_5)	Potassium chloride (K_2O)	Magnesium sulphate (MgO)
Magnesium M	42* (8.8)	45* (16.2)	5* (3.0)	8* (2.1)
Magnesium X	40* (8.4)	40* (14.4)	12* (7.2)	8* (2.1)
Magnesium C2	62* (13.0)	24* (8.6)	6* (3.6)	8* (2.1)
Magnesium Y	51* (10.7)	29* (10.4)	12* (7.2)	8* (2.1)
Magnesium J	41* (8.6)	30* (10.8)	21* (12.6)	8* (2.1)
MM1	50* (10.5)	18 3/4* (6.8)	15 5/8* (9.4)	15 5/8* (4.1)
W1	27* (6.0)	42* (16.0)	31* (20.0)	- -
W2	34* (8.0)	42* (16.0)	24* (16.0)	- -
J	45* (9.5)	33* (11.9)	22* (13.2)	- -
Y	56* (11.8)	30* (10.8)	14* (8.4)	- -

*Parts per hundred by weight

Compound fertilisers. Compound fertilisers are made up of two or more straight fertilisers compounded by chemical process. They are usually in granulated form. Several brands are available in the Malaysia market such as CHB, FPM, Behn Meyer, Superfos, Complasel and BASF compounds.

Slow release fertilisers. During the last few years, slow release fertilisers were introduced into the Malaysian market (*Table 6.10*). The advantages of this type of fertilisers are that they last longer in the soil and thereby reduce the frequency and labour of fertiliser application. They have been tried on rubber and look promising.

TABLE 6.10 SOME SLOW RELEASE FERTILISERS

Type	Approximate period of nutrient release (month)	Nutrient content (5%)			
		N	P	K	MgO
IBDU Woodace No.4	12-36	12	6	6	2
Kokei Field King	12-24	14	8	6	5
Greenpile	10-12	17	10	10	-
*Monsoon**	10	20	10	10	-
Agroblen (Osmocote)	12	16	8	9	3
*Nutricote**	12	16	10	10	-
*Macrocote**	12	16	4	10	-

*With trace or minor elements

Use of Fertilisers

In rubber cultivation, any type of fertiliser can be used as long as it contains nutrients required by rubber. But its nutrient contents must be adjusted to those of the RRIM mixtures. For example, NPK Yellow can be used in place of RRI Mixture Magnesium M, but the nutrient contents must first be adjusted accordingly:

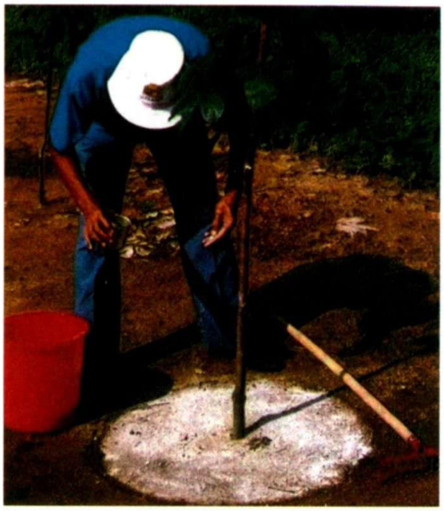
$$\frac{\text{Total nutrient \% in RRI Mixture Magnesium M} = 30.0}{\text{Total nutrient \% in NPK Yellow} = 40.0} = 0.75$$

To determine the quantity of NPK Yellow to be applied can be calculated by multiplying the quantity recommended for RRI Mixture Magnesium M by the factor 0.75. For example, 168 g of RRI Mixture Magnesium M is recommended for a ten-month old rubber, but only 126 g of NPK Yellow (168 x 0.75) is required. Because of the higher nutrient contents in compound fertiliser, less quantity is used. This may reduce labour in manuring and transport cost of fertilisers.

In terms of growth, there is not much difference between the mixture and the compound fertilisers, as rubber is a perennial crop. This proves that both have the same nutritional value. Therefore, fertilisers should be compared more in terms of costs, from the time of procurement until it is finally applied.

Placement of Fertiliser

For the first round of manuring, 113 g rock phosphate is incorporated into the planting hole at the time of planting. For the second and subsequent rounds, fertiliser is broadcast evenly around the base of the plant in a full circle, the radius of which depending on its age (*Table 6.11 and Figures 6.2 to 6.5*).



a) Fertliser is broadcasted around the base of the plant

b) Fertiliser is raked through the ground in full circle

Figure 6.2 Fertiliser application for young trees less than 15 months (circle broadcasting)

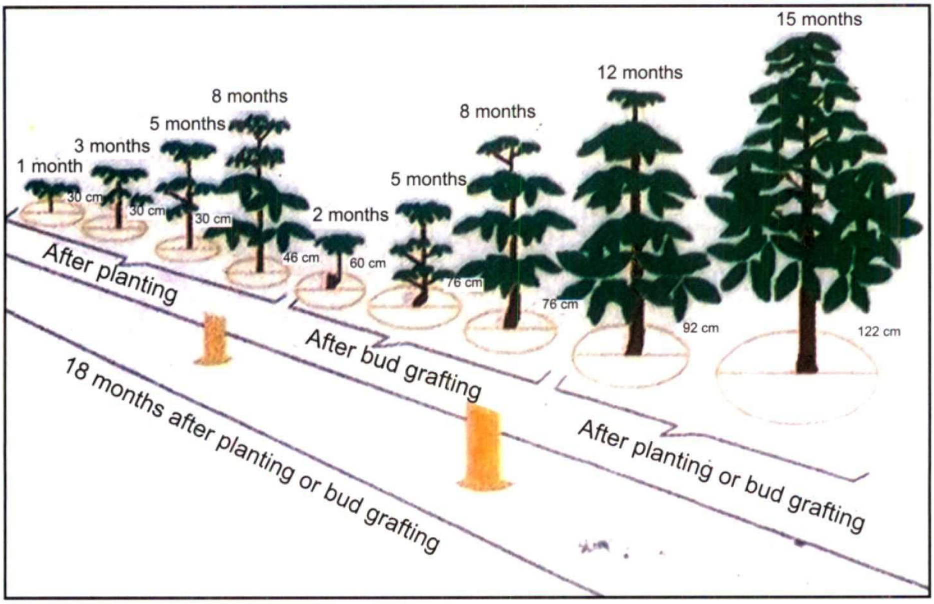


Figure 6.3 Diagram showing method of fertiliser application on young rubber

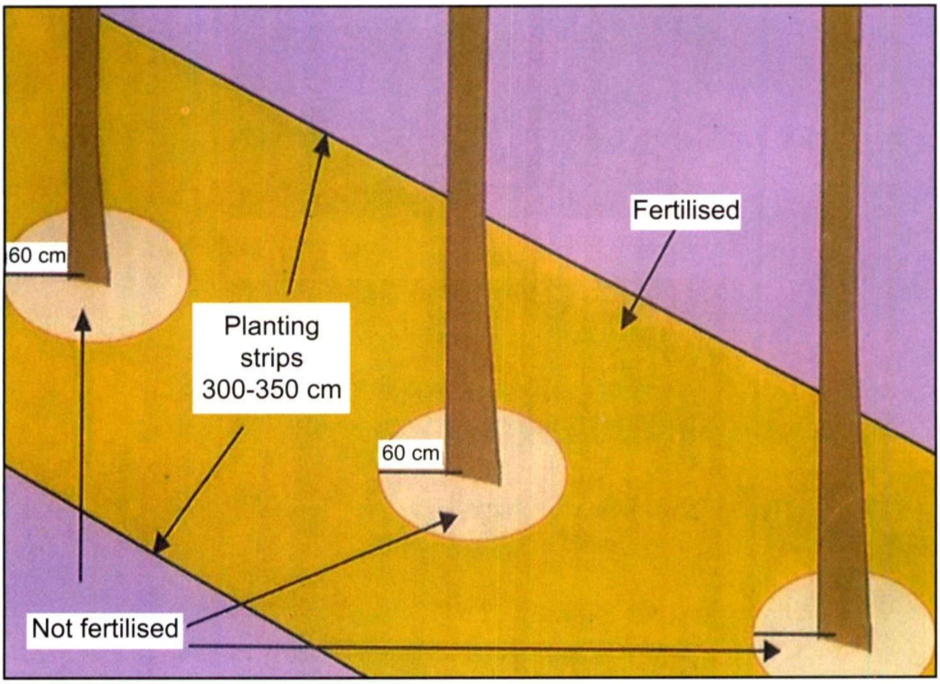


Figure 6.4 Diagram showing placement of fertiliser on mature rubber trees

(a) Broadcasting fertiliser along 2 m width strip for immature rubber

(b) Broadcasting fertiliser along 3-3.5 m wide planting strips

(c) Broadcasting fertiliser for mature trees

Figure 6.5 Application of fertiliser for immature and mature trees

TABLE 6.11: MANURING SCHEDULE FOR IMMATURE RUBBER IN THE FIELD

Month after planting	Amount of fertiliser (g/tree)
2	150[a]
5	150[a]
8	150[a]
11	150[a]
15	300[a]
19	300[a]
23	300[a]
28	450[a]
33	450[a]
39	700[b]
45	700[b]
52	700[b]
60	700[b]

a = Mix. Mag X (8.4 % N, 14.5 % P_2O_5, 7.2 % K_2O, 2.1 % MgO)
b = Mix. Mag Y (10.7 % N, 10.4 % P_2O_5, 7.2 % K_2O, 2.1 % MgO)
(Alternative fertiliser is NPK Yellow)

Schedule of Manuring

Manuring young rubber on inland soils. For inland soils, the schedule of manuring for young rubber is a general one. The types of fertiliser are dependent on the age of plants and the soil type. Low-potassium soils are usually the sandy soils, while medium-potassium soils are usually the loamy soils. In areas where legume cover crops are planted, large quantities of nitrogen are returned to the soil, thus no additional N fertiliser, such as ammonium sulphate is needed. In the early stages of growth, Magnesium X containing soluble phosphate should be applied to both types of soil. After that a change is made to RRI Mixture Magnesium M for the medium K soils and RRI Mixture Magnesium X for the low K soils for thirty four months. From thirty eight months onwards. RRI Mixture Magnesium C2 and RRI Mixture Magnesium Y are used for the medium K and low K soils respectively. Manuring of young rubber normally ends at sixty-two months, during which time the trees should be ready for tapping (*Table 6.12)*.

TABLE 6.12 GENERAL MANURING SCHEDULE FOR YOUNG RUBBER ON INLAND SOILS

Time of application (month after planting)	Type of fertiliser		Quantity per plant (g)	
	Medium K soils	Low K soils	Areas with legume covers	Areas without legume covers
1	RRI Mixture Mag X*	RRI Mixture Mag X*	57	57
2.5	RRI Mixture Mag X*	RRI Mixture Mag X*	85	85
4	RRI Mixture Mag X*	RRI Mixture Mag X*	85	85
5.5	RRI Mixture Mag X*	RRI Mixture Mag X*	113	113
7	RRI Mixture Mag X*	RRI Mixture Mag X*	113	113
9	RRI Mixture Mag X*	RRI Mixture Mag X*	113	113
11	RRI Mixture Mag X*	RRI Mixture Mag X*	170	170
12	Ammonium sulphate	Ammonium sulphate	-	113
13	RRI Mixture Mag M	RRI Mixture Mag X	170	170
14	Ammonium sulphate	Ammonium sulphate	-	113
15	RRI Mixture Mag M	RRI Mixture Mag X	170	170
16	Ammonium sulphate	Ammonium sulphate	-	113
18	RRI Mixture Mag M	RRI Mixture Mag X	170	170
19	Ammonium sulphate	Ammonium sulphate	-	170
21	RRI Mixture Mag M	RRI Mixture Mag X	227	227
22	Ammonium sulphate	Ammonium sulphate	-	227
24	RRI Mixture Mag M	RRI Mixture Mag X	227	227
25	Ammonium sulphate	Ammonium sulphate	-	227
27	RRI Mixture Mag M	RRI Mixture Mag X	284	284
28	Ammonium sulphate	Ammonium sulphate	-	227
30	RRI Mixture Mag M	RRI Mixture Mag X	340	340
31	Ammonium sulphate	Ammonium sulphate	-	284
34	RRI Mixture Mag M	RRI Mixture Mag X	340	340
36	Ammonium sulphate	Ammonium sulphate	-	340
38	RRI Mixture Mag C2	RRI Mixture Mag Y	340	340
40	Ammonium sulphate	Ammonium sulphate	-	340
42	RRI Mixture Mag C2	RRI Mixture Mag Y	454	454
44	Ammonium sulphate	Ammonium sulphate	-	340
46	RRI Mixture Mag C2	RRI Mixture Mag Y	454	454
48	Ammonium sulphate	Ammonium sulphate	-	454
50	RRI Mixture Mag C2	RRI Mixture Mag Y	454	454
53	Ammonium sulphate	Ammonium sulphate	-	454
56	RRI Mixture Mag C2	RRI Mixture Mag Y	454	454
59	Ammonium sulphate	Ammonium sulphate	-	454
62	RRI Mixture Mag C2	RRI Mixture Mag Y	454	454
65	Ammonium sulphate	Ammonium sulphate	-	454

*Use equivalent RRI Mixture Magnesium X that contains soluble phosphate
Mag = Magnesium

During the sixty-two months period, a total of twenty one rounds of fertiliser application is scheduled. This may give rise to difficulties in remote areas, hilly terrain and those facing logistic labour problems. *Table 6.13* gives an interim manuring schedule for young rubber on inland soils, in which the number of rounds have been reduced to seven.

TABLE 6.13 INTERIM GENERAL MANURING SCHEDULE FOR YOUNG RUBBER ON INLAND SOILS

Time of application	Type of fertiliser	Quantity per tree
At time of planting*	*Woodace No 4* or *Kokei Field King* or *Greenpile***	5 pellets 7 pellets 1 piece
Months after planting		
12	*Woodace No 4* or *Kokei Field King* or *Greenpile***	10 pellets 7 pellets 2 pieces
30	RRI Mixture Magnesium X	450 g
36	RRI Mixture Magnesium Y	650 g
42	RRI Mixture Magnesium Y	650 g
48	RRI Mixture Magnesium Y	650 g
54	RRI Mixture Magnesium Y	650 g

* To be placed in the planting hole
** *Greenpile* A Type 1
RRI Mixture Magnesium X and Y or their equivalents

Manuring young rubber on coastal clay soils. As usual 113 g of rock phosphate is incorporated in the planting hole at time of transplanting rubber. After that, fertiliser is not normally required, except when poor growth of rubber is encountered. In such cases, only nitrogenous fertiliser should be given, either ammonium sulphate or urea (*Table 6.14*).

TABLE 6.14 MANURING SCHEDULE FOR YOUNG RUBBER ON COASTAL CLAY SOILS

Time of application (month after planting)	Type of fertiliser (g per tree)	
	Ammonium sulphate or	Urea
2	56	28
5	84	42
8	170	85

Note: After eight months, fertiliser application can be continued if necessary, following the schedule in *Table 6.12* but using ammonium sulphate at half or urea at one quarter rate that of the mixture fertiliser.

Manuring mature rubber. In principle, fertiliser is given annually right up to three years before replanting. The type and rate are dependent on the soil series and whether or not the clone is susceptible to wind damage (*Table 6.15*).

TABLE 6.15 MANURING SCHEDULE FOR REPLANTED MATURE RUBBER (KG/HA/YEAR)

Soil series	Clones not prone to wind damage	Clones prone to wind damage
Rengam/Jerangau	400 (RRI Mixture J)	300 (RRI Mixture W1)
Munchong/Prang	350 (RRI Mixture Y)	250 (RRI Mixture W2)
Melaka/Gajah Mati/Tavy/Durian	300 (RRI Mixture Y)	200 (RRI Mixture W2)
Serdang*	400 (RRI Mixture J)	300 (RRI Mixture W1)
Telemong/Telega/Akob	400 (RRI Mixture Y)	275 (RRI Mixture W2)
Manik/Sogomana/Sitiawan	350 (RRI Mixture Y)	250 (RRI Mixture W2)
Klau	400 (RRI Mixture J)	300 (RRI Mixture W1)
Holyrood/Lunas**	450(RRI Mixture J)	350(RRI Mixture W1)
Selangor/Briah	50 (Urea + 50 (Potassium chloride)	50 (Urea + 50 (Potassium chloride)
Telok/Kranji/Linau	350 (RRI Mixture J)	280 (RRI Mixture W2)

*Manuring in February/March and May
**Manuring in February/March, May and August.

In the meantime a general manuring schedule for mature replanted rubber can be used (*Table 6.16*).

TABLE 6.16 GENERAL MANURING SCHEDULE FOR MATURE REPLANTED RUBBER (KG/TREE/YEAR)

Inland soil	Coastal clay soil		
RRI Mixture MM1 1-1.125	Ammonium sulphate 0.25	or	Urea 0.125

The recommendation in *Table 6.16* can be implemented only if the trees, during their immaturity period, had received adequate fertilisers, including the rock phosphate applied to the legume covers. Otherwise, RRI Mixture Magnesium Y at 1-1.125 kg and ammonium sulphate at 230 g per tree should be applied annually.

As Kuantan series soil is said to contain high quantities of N, P, Mg and Mn, it is sufficient to apply only potassium chloride at 0.25-0.5 kg per tree annually.

The best time to apply fertiliser to mature rubber is during the wintering period, that is approximately 100 days after leaf fall, as uptake of nutrient by the plant is most active during this period.

Nutrient Cycle

Nutrients constantly undergo numerous transformation processes, from the time of land clearing and initial establishment of rubber right up to the various stages of development of the rubber plantation. Although the individual processes may head in different directions, the nutrients generally move through a cycle. Basically, the cycle consists of two main phases – the plant phase and the soil phase. The inter-relationships of the two form the basis of the ecosystem in the rubber plantation. The transfer of nutrients between soil and vegetation, the transformation of nutrients in the soil, losses of nutrients from the cycle and gains of nutrients in the soil, losses of nutrients from the cycle and gains of nutrients by the cycle are illustrated in *Figure 6.6*.

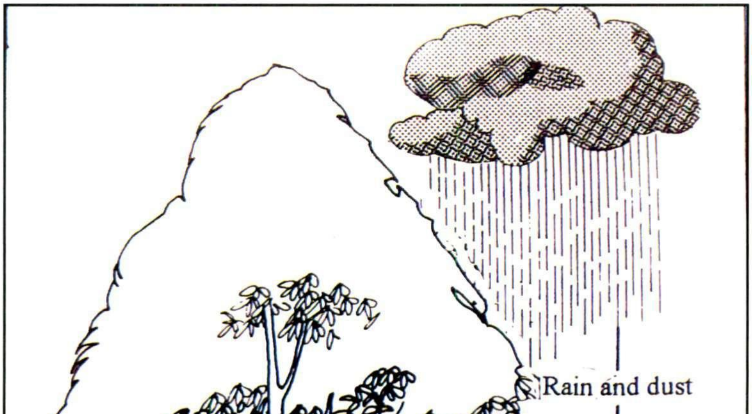


Figure 6.6. Nutrient cycle in the rubber plantation

REPLACEMENT AND THINNING OUT

Among the maintenance work required in rubber cultivation are replacement of failed plants and thinning out. Brief descriptions of these two operations are given in the text below.

Replacement

During the early stages of growth, rubber plants which fail to survive are replaced. As the age of the rubber tree increases, all replacement work to be carried out must be balanced with thinning out. But when a group of nearby trees die, some have to be replaced, if not all.

When carrying out replacement, trees of the same girth size are used, so that they too reach maturity at the same time as the rest, in the same area. This operation can easily be implemented if the 10% reserved planting materials were included in the original transplanting work. Replacement work should not be carried out at a failure point where the crowns of the two adjacent trees have touched each other.

Thinning Out

Thinning out is the removal of selected trees from a plantation. In the smallholding sector, thinning out work is minimal and limited, too. This is because of the limited nature of the smallholding area, where every tree counts.

Previously, it has been the practice in the estates sector to implement a thinning out programme of as high as 20% from the original density. Estates which used clonal seedlings as the planting materials, used to thin out as high as 30% of the stand. This is due to the variations in characteristics of seedlings materials. Today, this operation is still carried out, but on a lower scale. The criteria for thinning out are as follows:

- Poorly growing trees known as runts
- Badly deformed trees
- Diseased trees which are beyond treatment
- Badly damaged trees which are beyond repair
- Poor yielding trees (for clonal seedling materials only)

Thinning out can be done by uprooting, felling or poisoning. Thinning out results in more space for the rest of the tree population, and reduces inter-tree competition. It also reduces wastes on fertilisers and other tree maintenance work. In a mature stand, thinning out results in higher yield per tree and better bark renewal.

PRUNING

A rubber tree does not normally require branches on the stem below a height of 3 metres. This is because a clean smooth stem is needed to facilitate tapping when the tree matures. In the estates sector, this height may differ from estate to estate, depending on the exploitation policy of each company. To obtain a smooth clean stem, all the side branches are pruned off from time to time. Pruning is the removal of any part of the plant by physical cutting. In rubber, it is mostly done to the branches. The pruning technique is important so that very little disturbance is caused to the tree growth. It can be divided into two categories - corrective and controlled pruning.

Objectives of Pruning

The objectives of carrying out corrective pruning are to:

- correct defective trees resulting from defective branchings
- stabilise the tree
- reduce wind damage incidence at a later stage of tree growth

The objectives of implementing controlled pruning are to:

- obtain a straight clean stem for tapping
- retain leaves on the plant for as long as possible
- enhance growth, thus, reducing immaturity period (*Table 6.17*)
- improve yield (*Table 6.18*)

TABLE 6.17 EFFECT OF CONTROLLED PRUNING ON GROWTH AND TAPPABILITY OF RRIM 600

Experiment	Treatment	Five years later	
		Girth (cm)	Tappability (%)
1	Estate pruning*	47.2	36.5
	Controlled pruning	49.6	53.4
2	Estate pruning *	44.9	49.7
	Controlled pruning	46.1	59.1

*Pruning of all branches as they appear to obtain a 300 cm clean straight stem

TABLE 6.18 EFFECT OF CONTROLLED PRUNING ON TAPPABILITY AND YIELD

Treatment	Tappability (%)	First year average yield	
		g/t/t	kg/ha
EP	34.5	35.9	630.8
IL-4FP	47.3	34.8	812.0(129)
IL-2WP	46.9	35.9	794.9(126)
IL-3WP	39.1	32.5	603.3 (96)
IL-PCP	48.7	38.3	829.8(132)
IH-2WP	45.8	37.9	791.4(126)
IH-3WP	53.7	36.4	880.1(140)
IH-PCP	52.6	40.5	955.2(151)

*Yield for the first half year tapping was from one replicate and subsequently yield from two replicates, tapping system used was 1/2S d/3
EP = Estate pruning, IL = Induced low, IH = Induced high; 4FP = four flush pruning, 3WP = Three whorl-branch pruning; 2 WP = Two branch pruning, PCP = Planter's Conference pruning
Figures within brackets are percentages of treatment EP.

Corrective Pruning

For budded planting materials, it is important to ensure that only a single scion shoot (sprouting from the budpatch only) grows to form the required tree. Any other shoot that appears must be pruned off. From this, a strong straight and healthy stem with a central branch (which in fact is part of the stem) known as the leader branch must be allowed to develop. Side shoots which may appear from whorl to whorl are normally allowed to grow unless they are unsatisfactory and require correction, such as:

- Heavy side branch
- Vigorously growing side branch overtaking the leader
- Multiple branches at the top with active leader
- Multiple branches at the top with retarded or dead leader
- V-fork branching at the terminal with retarded or dead leader (*Figure 6.6*).

To remedy the above situations, the following steps are recommended:

- Prune off the heavy side branch flush with the stem
- Prune to shorten the vigorous side branch at a level lower than the leader
- Prune the multiple branches at the terminal, except the leader, if it is still active
- Remove the multiple branches at the terminal, if the leader is dead or retarded, leaving one that is likely going to become the leader
- For V-fork branching with dead or retarded leader, remove one arm of the V-fork (*Figure 6.6*)

Controlled Pruning

For controlled pruning, no pruning of side shoots or branches that appear on the first or second whorl is carried out. But when the third whorl of branches appears, all branches at the lowest whorl are removed. The plant continues to grow, and when there, are three whorls of branches on it, all branches at the lowest whorl are removed. Pruning trees with less than three whorls of branches can also be carried out if the ages of the trees reach seven months and branches at the lowest whorl have four flushes of leaves. Branches are induced on plants which have no branches and have attained a height of 2 metres. Meanwhile, the tree continues to grow, and the same pruning operation is repeated until 3 m of clean straight stem is achieved. This normally takes about eight to ten months (*Figure 6.7*). After that the tree is allowed to continue growing until it reaches maturity.

(a) Vigorous side branch overtaking the leader

(b) Shortening the vigorous side branch

(c) Too many branches at the top with retarded leader

(d) Pruning all branches including the leader, leaving one to assume the leader branch

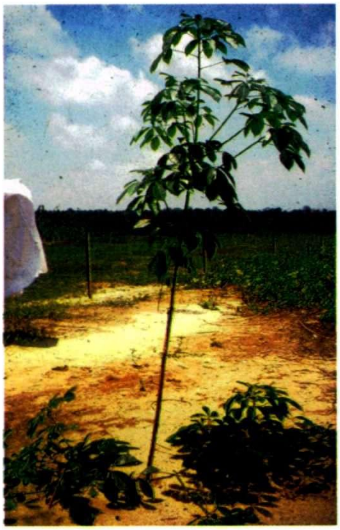
Figure 6.7 Example of corrective prunings

(a & b) Pruning not required on plants with one or two whorls of branches

(c & d) All lower branches need to be pruned leaving the plant with three whorls

(e & f) Pruning of the lowest whorl branches is carried out when three whorls of branches have been formed on the plant

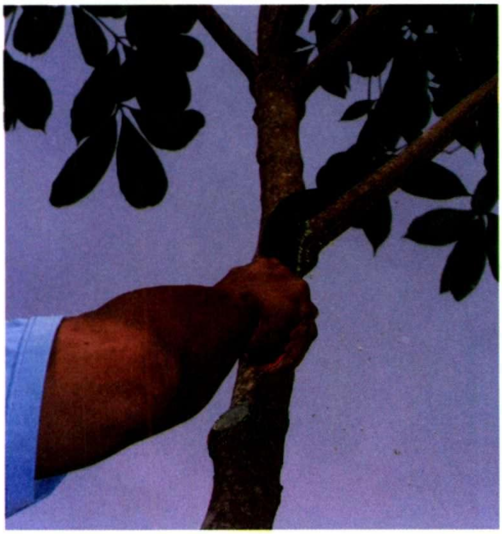
(g & h) Pruning of plants with less than three whorls of branches after seven months, provided the lowest branches have four whorls of leaves on them



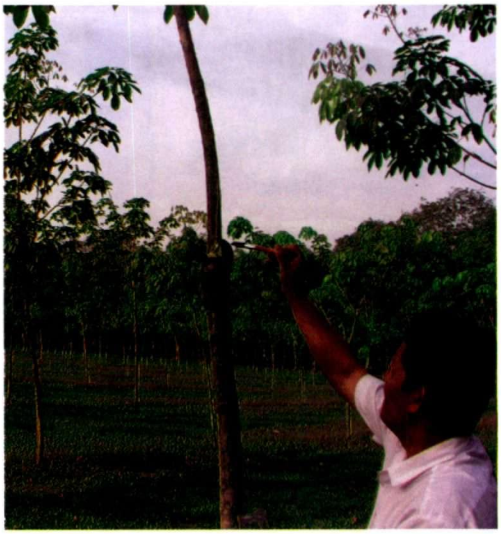
(i & j) Inducing branches on plants that do not develop branching after reaching a height of 2 m

Figure 6.8 Various types of controlled pruning

Pruning should be done to avoid emergence of unwanted side shoots. It must be done by a pair of sharp scateurs, pruning saw or rollcut to obtain a clean cut. All surfaces must be treated with suitable fungicidal wound dressing such as the *Shell Tree Dressing* (*Figure 6.8*).



(a) Pruning a branch using a pruning saw



(b) Applying wound dressing to the cut surface

Figure 6.9 Pruning technique

It can be noted from *Table 6.24* that the last treatment IH-PCP gives the best response in terms of yield (151% over control) and, to a certain extent, the tappability rate of 52.6%. But the pruning technique involved is too complex and is not very practical. The next best result comes from treatment IH-3WP which gives the highest tappability rate of 53.7% and the yield of 140% of control EP. This is the three-whorl branch pruning currently recommended.

Controlled pruning can also be termed as delayed pruning. By delaying pruning of the side branches, leaves are retained for a much longer period on the tree, thus more efficient photosynthesis takes place. This in turn, enhances growth and later, the yield.

BRANCH INDUCTION

It has been established that leaves play an important part in the growth of plants, including rubber. This is because, the chlorophylll in the leaves is the medium for photosynthesis. The large number of leaves present on the plant results in large leaf area for more efficient trapping of sunlight and thus enhances photosynthesis. Leaves are found on branches. Therefore, the emergence of more and early branches result in the early emergence of large number of leaves on the plant. Early branching can be induced.

Objectives of Branch Induction

The main objectives of inducing early branching on the rubber tree, are to:

- obtain large number of leaves at an early stage of growth
- obtain large total leaf surface area for better trapping of sunlight
- stimulate more efficient manufacture of plant food
- enhance growth of rubber (*Table 6.25* and *Figure 6.9*)
- reduce the unproductive period of the rubber tree
- reduce the overall tree height (*Table 6.26* and *Figure 6.10*)

TABLE 6.19 EFFECT OF BRANCH INDUCTION ON GROWTH OF FOURTEEN MONTHS OLD TREES

Treatment	After induction (cm)			
	0 month	6 months	9 months	12 months
Without induction	9.4	13.9	16.1	18.1
With induction	9.1	13.7	16.6	19.1
Difference	-	+0.1	+0.8	+1.3

TABLE 6.20 EFFECT OF BRANCH INDUCTION ON TREE HEIGHT OF FOURTEEN MONTHS OLD TREES

Treatment	Height after induction (m)	
	0 month	12 months
Without induction	4.5	7.4
With induction	4.5	6.6
Difference	-	0.8

a) Non-branching plant growing tall and becoming unstable

b) Induced-branching plants are shorter, stable and girth well

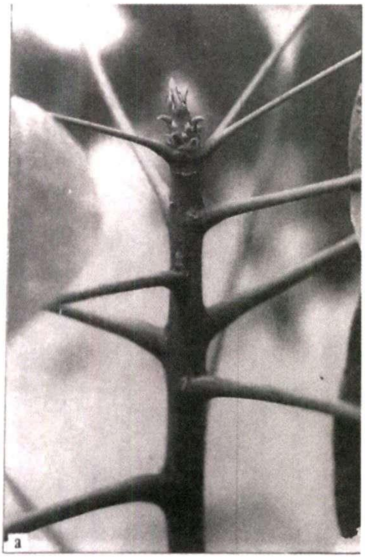
Figure 6.10 Effect of branching on the rubber tree

Method of Branch Induction

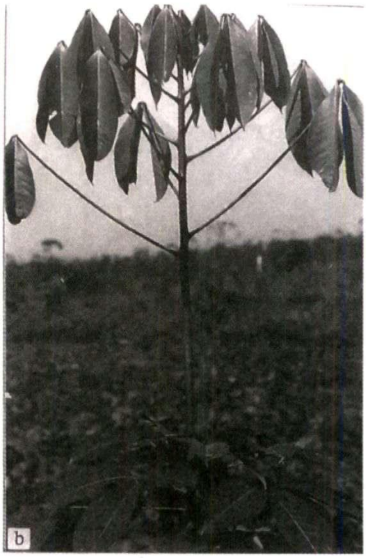
Branch induction is normally carried out on trees with late branching habit such as RRIM 600. It is also done on other trees that do not branch on reaching a height of 2 metres. The technique involves the covering of the terminal shoots by leaf capping or folding, depending on the condition of the terminal shoot. Terminal shoot conditions are divided into five stages of growth i.e. bud-break less than 2 cm, bud-break more than 2 cm, leaflet, pendant and hardened stages.

For terminals with bud-break less than 2 cm, pendant and hardened stages, the top whorl of leaves are folded down to enclose the epical bud. The leaves are tied with a rubber band going round twice (*Figure 6.10*). This technique is called the leaf fold method. For terminals with bud-break more than 2 cm and leaflet stages, three pieces of matured rubber leaves are taken and folded to form a cap enclosing the epical bud. The cap is tied with a rubber band going round twice. This method is known as the leaf cap method (*Figure 6.10*).

The folding and capping are removed after three to four weeks, during which time side shoots have started to appear (*Figure 6.10*). Success of branch induction can reach as high as 80% and as low as 60%.



(a) Bud-break terminal

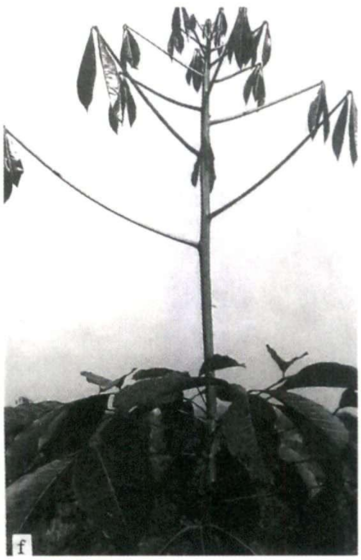


(b) Pendant terminal

(c) Hardened terminal

(d) Covering the terminals by leaf folding

(e) Bud-break more than 2 cm terminal



(f) Leaflet terminal

(g & h) Covering them by capping

(i & j) Induced branchings five weeks later

Figure 6.11 Inducing branches

The ideal branching habit for the rubber tree is a strong straight stem extending right up to the tip of the tree. In other words, the existence of a main central branch known as the leader; the rest are only side branches, relatively smaller in size, well-arranged along the leader, with wide angles. The leader is important to the rubber tree as its function is to balance the crown and to provide stability.

There are also other methods of inducing branches on to the rubber tree and they are listed below:

- Pollarding the crown
- Ringbarking the stem
- Ringcutting the bark
- Defoliating the leaf completely
- Leaf trimming with chemical spraying

In the first method, the tree loses its leader and this is not safe for the tree. Furthermore, the branches that emerge to take the place of the leader may not be desirable. At the same time, the shock to the tree is great. In the second and third methods, the success of inducing branches is low and they mostly produce unhealthy flushes. Defoliating the tree completely, which is the fourth method, gives high branching success, but will result in a severe shock to the tree. Therefore, it is not recommended. Defoliating the tree gives almost 100% success, but the chemicals used (Atrinal and Benzyladenine) are expensive.

The leaf fold and the leaf cap methods described earlier in the chapter are still preferred. They are simple, fairly effective and cheap.

REPAIRS AND GENERAL MAINTENANCE

Apart from maintaining crops, there are a few other operations which are equally important and have to be executed. These can be considered as repair and general maintenance work.

Materials, equipment, amenities, buildings, infrastructure and machinery which are damaged or worn out due to long usage need to be repaired when necessary. This is an on-going operation covering the whole economic life of the plantation.

In hilly areas, terraces which are broken or defective must be repaired so that they are functional at all times. In the low-lying areas, drains that are silted, blocked and grown with weeds must be cleaned, cleared and deepened so that flow of water is always efficient. If there are roads on the plantation, they should be regularly graded with the side drains cleaned and desilted. Rotted fencing posts must be replaced and damaged fencing wires repaired. Besides these, maintenance of buildings, stores, factories, field equipment agricultural and factory machinery is equally important.

In normal management practices, worn out items are usually repaired or replaced when necessary. But there are other works that require regular periodic maintenance such as machinery and motorised vehicles. It is therefore important for the plantation to draw up schedules for executing such works so that they are carried out when the time comes. For that purpose, adequate spare parts of such machinery and other items must be made available as replacements. All these are part and parcel of good plantation management.

TREE GROWTH CENSUS

Rubber trees are measured for their girths from time to time to assess their performance in terms of growth. This is known as tree girth census or survey. This is considered as an important post-planting field operation.

Objectives of Girth Census

Like all other plantation activities, implementing tree growth census also has its own objectives, which are to:

- monitor growth of the planted crops
- make corrections where necessary
- find out whether other inputs are required by the plants
- determine the exact time when the trees can be brought into tapping
- make preparations for tapping.

Method of Girth Census

Tree girths are measured from time to time, beginning twelve months from planting. It is repeated every six months until the girths reach 35 cm, which is approximately three and a half to four and a half years after planting. After that, census is done every three months. This is known as tapping census or survey.

Measurements of girths of a large number of trees in an area give more accurate information of their growth status. In fact, if possible all the trees in an area should be surveyed. But this can entail a lot of work incurring additional cost. Therefore, only a few selected trees are taken to represent the whole tree population of an area. The same trees are again measured at subsequent survey rounds. Measurements are made in centimetres, taken at 150 cm for buddings and 75 cm for clonal seedlings, from ground level. A black band mark is made on the stem of trees measured and they are subsequently numbered. This is to ensure that the same trees are measured at the height in subsequent surveys rounds. Details regarding the census, especially the girth measurements, are entered in a special record book. Below are some suggestions as to the selection of samples for tree girth census:

- Eight to twelve trees per hectare from selected planting rows are surveyed
- For every 10 ha area, a 0.25 ha block of trees is surveyed
- Three to five percent of the total number of trees in an area surveyed are taken from selected planting rows of at least twenty consecutive trees per row
- All trees along the diagonals of an area are surveyed
- For smallholding area below 2 ha, all trees are surveyed.

Girth measurements of trees approximately below half the average size should not be recorded as this can drastically bring down the average girth. A record of runt (R) should be entered instead. For the vacant points, an entry of V should be made. When completed, a rough plan of the area should be drawn, showing the position of the planting rows and the path or route taken in carrying out the census. This is to facilitate subsequent survey operations. This work can be made easy if the area already has a point plan as recommended in an earlier chapter.

Benefit of Census Records

All measurements taken are totalled up, and then divided by the number of trees measured. This gives the average girth of the trees measured in the whole area. This average should be compared with the previous one taken six months ago to obtain feedback on the growth situation of the trees.

CHAPTER 7

WEEDS AND THEIR CONTROL

WEEDS

Weeds are defined as plants that grow where they are not wanted. They are not planted but self-grown.

Advantages of Weeds

There are several advantages for the existence of weeds on the rubber plantation, and among them are :

- Weeds help to reduce soil erosion by reducing the direct impact of rainfall on the soil surface
- They keep the soil surface cool by reducing the direct impact of sunlight on the soil surface
- They help to preserve moisture in the soil
- They add organic matter to the soil from their leaf litter
- They provide food to animals
- Certain weed species are used in traditional medicines

Disadvantages of Weeds

The disadvantages of weeds outweigh their advantages, and they are as listed below:

- They compete with rubber for water, nutrients, sunlight, air and space *(Table 7.1)*
- Certain weed species inhibit growth of rubber *(Table 7.2)*
- They delay maturity of rubber *(Table 7.3)*
- They affect yield
- They increase cost of plantation maintenance
- They provide sanctuaries for pests of rubber
- They affect efficient flow of water in drains

TABLE 7.1 EFFECT OF WEED UNDERGROWTH ON GROWTH OF RUBBER

Field block	Age of rubber (Month)	Girth of tree with undergrowth slashed (cm)	Girth of tree with undergrowth unslashed (cm)
I	36	34.01	30.40
	42	33.93	32.87
II	36	30.02	29.03
	42	32.97	30.33
III	36	37.69	35.53
	42	45.54	42.72

TABLE 7.2 EFFECT OF WEEDS ON GROWTH OF RUBBER FIVE YEARS AFTER PLANTING (GIRTH OF TREE IN CM)

Types of weed	Inland soil	Coastal clay soil
Imperata cylindrica	18	24
Grasses	36	40
Legumes	40	41

TABLE 7.3 EFFECT OF WEEDS ON IMMATURITY PERIOD OF RUBBER

Types of weed	Melaka series soil (month after field budding)	Seremban series soil (month after planting)
Mikania micrantha	80	63
Grasses	68	59
Legumes	61	56

Prevention of Weed Infestation on Rubber Plantation

The current cost of weed control on a rubber plantation is very high, amounting to 25% of the total immature cost. Therefore, preventing weeds from dominating the plantation is very much cheaper.

When clearing land for plantation development, the felled vegetations are burnt and the heat produced scorch the weed seeds in the soil, thus preventing them from germinating. The soil can be tilled (ploughed and harrowed or rotovated) so that roots of weeds are exposed to sunlight and finally dried. Cleared land must not be left exposed for too long. Entry of weed seeds from nearby areas must be prevented. Legume creeping cover crops must be established immediately. Before planting the legume cover crop seeds, make sure that pre-emergent herbicide is blanket-sprayed to the area.

Method of Weed Control

Weeds that are already on the plantation must be controlled regularly to keep them suppressed all the time. This can reduce their competitive effect on rubber. There are two areas where weed control is required – weeds growing in the inter-rows and weeds growing along the planting strips or terraces. In practice, the inter-rows are established with legume cover crops and weed control is limited to those weeds growing within them. This is taken care of by legume purification. Areas that are not planted with legume cover crops will certainly be infested with weeds that require minimum control. Such weeds should be controlled by slashing so that they are not taller than 60 centimetres. Total eradication of inter-row weeds is not recommended, especially on hill slopes, except perhaps, for the very noxious one such as *Imperata cylindrica*. Weeds growing along the planting rows of two metres width or terraces must be controlled to the maximum. This can be done by manual hoeing (*cangkul*) or chemical herbicide spraying. Nowadays, manual hoeing is quite costly and the process is quite slow. Moreover, weed regeneration is very fast as the weed stumps left in the soil are able to reproduce new shoots within days. This method can also cause damage to rubber roots, and is therefore undesirable. Period of control by herbicide spraying is very much longer, and in some cases up to three months or more. Rubber roots are not damaged and the cost is very much cheaper.

In the initial stage of rubber growth, weed control can be frequent, but as the trees grow older, the frequency becomes less and less. This is due to the shading effect of rubber on weed growth *(Table 7.4)*.

TABLE 7.4 WEED CONTROL ROUNDS BY HERBICIDE SPRAYING

Year	Weeds along planting strips	Weeds in the inter-rows
1	Four to six	Six
2	Four to six	Four
3	Four	Three
4	Four	Two
5	Four	One
6	Three	One
7	Two	One
8	Two	One
9	One	-

Type of Herbicide

There are various types of post-emergent herbicide available in the Malaysian market. Their mode of action is systemic as well as non-systemic. Systemic herbicides are either translocative or hormonal in action, while the non-systemic kills by contact. In Malaysia, hundreds of weed species are found on the rubber plantation and not all of them have similar growth characteristics. There is no single herbicide that can control all of them. Some herbicides are only effective on broad-leaved weeds while others on grasses and some on woody or shrubby growths. Thus, when mixed weed species exist on a plantation, a mixture of herbicides has to be used. *Tables 7.5 & 7.6* are for treatment of weeds in young rubbr area and mature rubber plantations, respectively some noxious weeds are listed in *Figure 7.1*.

Attention is to be given when spraying weeds along planting strips or terraces, the rate and volume should be reduced by using the following formula:

$$\text{Volume per strip per hectare} = \frac{\text{Rate per hectare x width of planting strip}}{\text{Distance between planting rows}}$$

Example:

Rate of *Roundup* per blanket hectare	=	3 litres		
Distance between planting rows	=	5 metres		
Width of planting strip	=	2 metres		

Rate of *Roundup* per strip hectare = $\frac{3 \times 2}{5}$ = 1.2 litres

Volume of water per blanket hectare	=	450 litres		
Distance between planting rows	=	5 metres		
Width of planting strip	=	2 metres		
Volume of water per strip hectare	=	$\frac{450 \times 2}{5}$	=	180 litres

TABLE 7.5 TYPE OF HERBICIDES FOR YOUNG RUBBER AREA

Type of weeds	Type of herbicides	Rate per hectre	Rate for 18 litre (knapsack sprayer)
Broad and small leaves, e.g.: *Mikania micrantha* *Asystasia gangetica*	*2,4-D Amin* *Ally 20DF* *Basta 15*	30 litres 0.75 kg 3.3 litres	120 ml 3 g 132 ml
Small grass, e.g.: *Paspalum conjugatum* *Elicine indica*	*Basta 15* *Roundup*	3.3 litres 3.0 litres	132 ml 120 ml
Mixed grass with broad and small leaves	*Roundup* *Basta 15* *Hat-Trick* *Starmix* *Roundup + Ally 20DF*	3.0 litres 3.3 litres 4.4 litres 2.15 litres 3 litre + 0.15 kg	120 ml 132 ml 176 ml 86 ml 120 ml + 6 g
Noxious Weeds, e.g.: *Imperata cylindrica* *Penisetum polystachion* *Ischaenum muticum*	*Round up* *Touchdown*	6.0 litres 6.0 litres	240 ml 240 ml
Woody weeds, e.g.: *Chromolaena odorata* *Melastoma malabathricum* *Clidemia hirta*	*Starane 200* *Garlon 250* *Banvel 400* *Tordon 101* *Ally 20DF*	1.0 litres 1.25 litres 2.0 litres 2.0 litres 0.15 kg	40 ml 50 ml 80 ml 80 ml 6 kg
Ferns, e.g.: *Dicranopteris linearis* *Stenochlaena pelustris*	*Basta 15* *2,4 – D Amine +* Sodium chlorate	6.0 litres 3.0 litre + 20 kg	240 ml 120 ml + 800 g

The rates of herbicide recommended in *Tables 7.5 and 7.6* are for controlling weeds in unshaded or open areas, as in the case of very young rubber areas. Under shaded conditions, such as in mature rubber areas, the rates can be reduced by 25% in the same volume of water.

TABLE 7.6 TYPE OF HERBICIDES FOR MATURE RUBBER AREA

Type of weeds	Type of herbicides	Rate per hectare	Rate for 18-litre knapsack sprayer
Mixed grass with broad and small leaves	*Roundup* *Basta 15* *Hat-Trick* *Starmix* *Roundup + Ally 20DF*	3.0 litres 3.3 litres 3.0 litres 1.5 litres 1.5 litre + 0.075 kg	120 ml 132 ml 120 ml 60 ml 60 ml + 3 g
Noxious Weeds, e.g.: *Imperata cylindrica* *Penisetum polystachion* *Ischaenum muticum*	*Roundup* *Touchdown* *Assault 100A*	3.0 litres 3.0 litres 5.0 litres	120 ml 120 ml 200 ml
Woody weeds, e.g.: *Chromolaena odorata* *Melastoma malabathricum* *Clidemia hirta*	*Garlon 250* *Starane 200* *Banvel 400* *Tordon 101* *Ally 20DF*	2.0 litres 1.25 litres 2.0 litres 2.0 litres 0.15 kg	80 ml 50 ml 80 ml 80 ml 6 g
Ferns, e.g.: *Dicranopteris linearis* *Stenochlaena pelustris*	*Basta 15* *2,4-D Amine +* Sodium chlorate	6.0 litres 3.0 litres + 20 kg	240 ml 120 ml + 800 g

(a) *Assystasia gangetica*

(b) *Dicranopteris linearis*

(c) *Stenochlaena palustris*

(d) *Chromolaena odorata*

(e) *Eleusine indica*

(f) *Ischaemum muticum*

(g) *Mikania micrantha*

(h) *Pennisetum polystachyion*

(i) *Melastoma malabathricum*

(j) *Imperata cylindrica*

Figure 7.1 Several noxious weed species

Technique of Spraying

Spraying of herbicide must be carried out systematically so that its effect on weeds is almost total, avoiding at the same time wastage of the spray solution. For blanket spraying, the area should first be demarcated into blocks, the width of which is double the spray swath of the nozzle, and this is usually four metres. When spraying weeds in planting strips or terraces, just walk along the strips, releasing the spray solution at the same time. A knapsack sprayer of 18-litre capacity *(Figure 7.2)* fitted with fanjet nozzle 248 5/64 *(Figure 7.3a)* for blanket spraying and floodjet nozzle 148 5/64 *(Figure 7.3b)* for strip spraying is used. The herbicide solution can be prepared in bulk using a 200-litre drum or in small volume of 18 litres using a kerosene tin of 20-litre capacity. When preparing herbicide solution, water must first be ready and measured, and if more than one chemical is used, they should be diluted one by one to avoid precipitation. The solution should be well stirred and then transferred into the knapsack sprayer through a strainer.

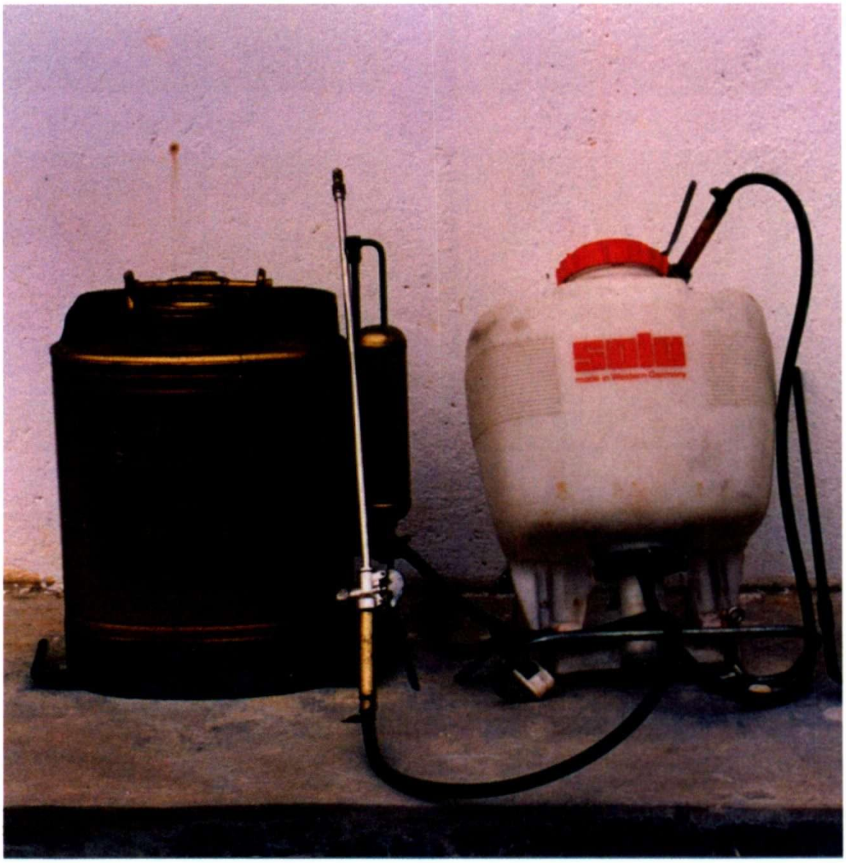
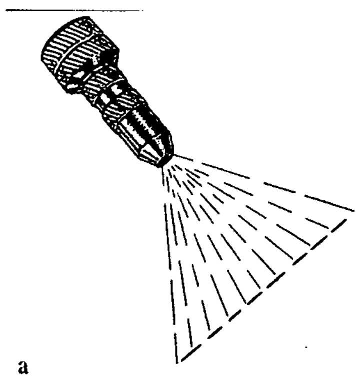
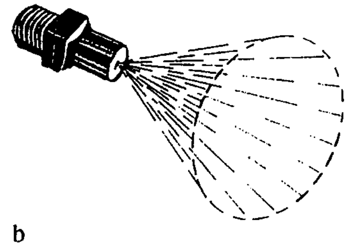


Figure 7.2 Knapsack sprayers of 18 litres capacity - brass (left) and PVC (right)



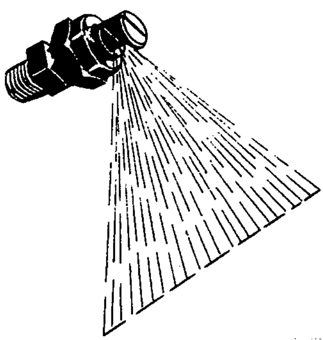
a



b

(a) Fan jet

(b) Flood jet



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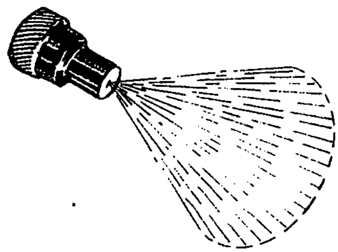


d

(c) Hollow conical jet

(d) Solid jet

Figure 7.3 Various types of nozzle

Pressure of one kg per square centimetre is given into the sprayer body. This can be obtained by pumping it six times. The speed of walking during spraying is two km per hour. To obtain a spray swath of two metres, the nozzle is raised 60 cm above ground. It is very important to have a uniform spraying pressure all through, by giving a pump for every step taken. Contact of herbicide solution with the tree must be avoided *(Figures 7.4 and 7.5).* Continue spraying until the sprayer is empty. Refill the sprayer and continue spraying until the area is fully covered. All equipment should be washed clean immediately after use.

To obtain good result, spraying should be carried out in the early hours of the morning or late afternoon to avoid evaporation of the spray solution. The period of control is two to three months, depending on the shade condition. However, respraying is only carried out when the regeneration of weeds has reached 60 percent.

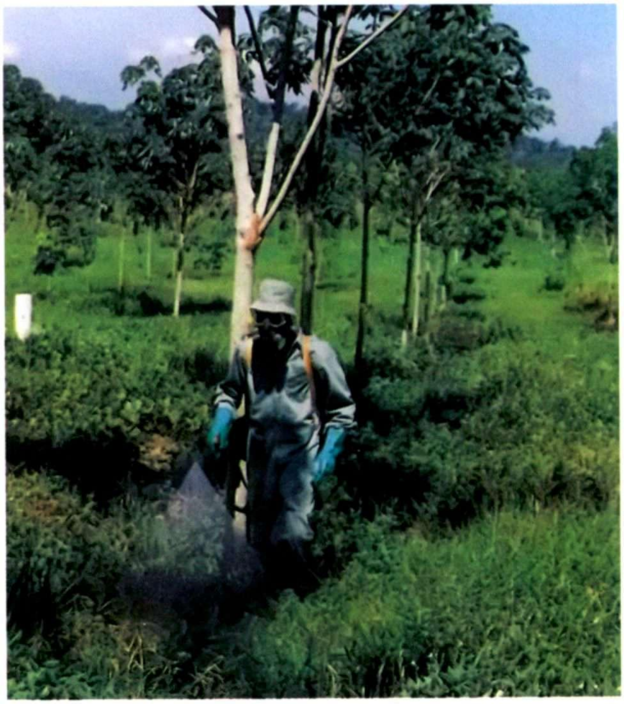


Figure 7.4 Spraying herbicide along planting row

Figure 7.5 Planting strip after spraying of herbicide

Precaution in Handling Herbicides

In the course of handling herbicides, precautions must be taken with regards to safety to the planted crops, as well as animals and human beings. The following are some guidelines:

- Keep herbicides in safe place
- Before using herbicides, read and understand the labels thoroughly
- Use suitable protective clothing *(Figure 7.6)*
- Do not eat, drink or smoke when handling herbicides
- Avoid inhaling concentrated herbicides
- Do not mix herbicides near crops, fire or waterways
- Do not blow or suck by mouth blocked sprayer nozzle; use other tools and methods to clear it
- Do not reuse empty herbicide containers; destroy and bury them
- Immediately wash body and clothing after handling herbicides
- Consult a doctor immediately if you feel unwell.

Figure 7.6 Use suitable protective clothing when spraying

Chemical weed control is not only costly, but also hazardous to health; and, to a certain extent, it pollutes the environment. Therefore, where possible, this operation should be kept to the minimum. When only one weed species is present on a plantation, use the type of herbicide that is effective on it. Avoid the general herbicide mixture. Sometimes, repeated use of a particular herbicide on certain weed species may result in the colonisation of tolerant or resistant species. This needs careful observation and corrective action must be taken to avoid wastage. Another point to consider is to go for very low volume spraying, using the controlled droplet applicator (CDA) or motorised spraying for the larger areas. Experiments have proved that there are substantial savings in cost.

During the 1980's, RRIM carried out studies on sheep rearing and grazing on rubber plantation and found that sheep can be an important and effective agent for biological weed control. There was a saving of 17-30% in weed control cost and at the same time girthing of rubber improved by 11 percent. Income from the sale of sheep reduced the hardship faced by the farmers during the immaturity period, while during the maturity period of rubber it became an added income.

Establishment and maintenance of pure legume cover crops, and the planting design of rubber itself can also reduce weed problems on a plantation. The triangular and square-shaped planting designs encourage early closure of the rubber canopy, resulting in less transmission of light into the plantation and hence less vigorous growth of weeds. All these finally lead to the reduction in the use of chemical herbicides and consequently the cost of weed control.

CHAPTER 8

TREATMENT OF MALADIES AND INJURIES AND CONTROL OF PESTS

ROOT DISEASES

Root diseases are considered as the most serious of all diseases in rubber cultivation, because they can kill the tree. They are caused by fungi, which initially infect the root surface only. After some time, they penetrate the wood tissue, causing the root to rot and eventually kill the tree. Root diseases can spread from tree to tree by root contact. They can also be spread by the spores which enter the roots through any exposed tissue in the stem or branch resulting from wounds. Root diseases originally came from jungle trees and spread to the cultivated crops like rubber, when plantations started to develop. Besides rubber, a number of other perennial crops are hosts to root diseases, too.

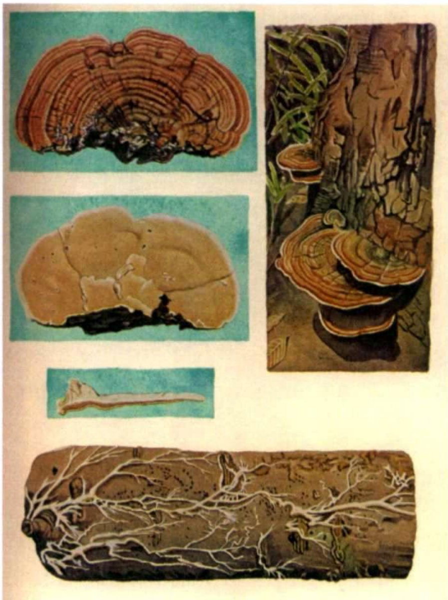
Types of Root Disease

Six types of root disease are known to infect rubber, out of which three are the major ones. They are white, red and brown root diseases. The names are given according to the colour of the causal fungi.

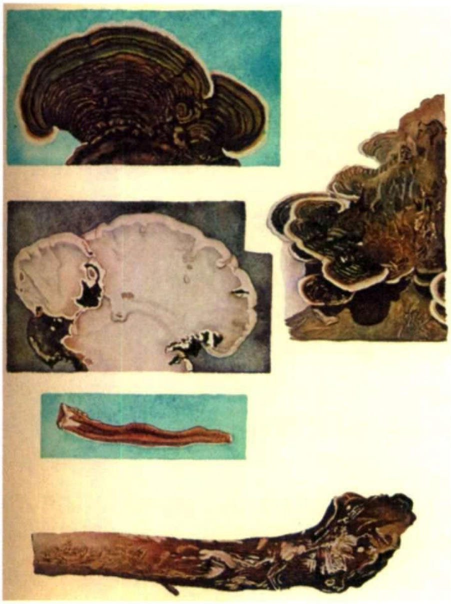
White root disease. The name of the fungus is *Rigidoporous lignosus.* It is white in colour. The rhizomorphs are firmly attached to the root. The rhizomorphs are threadlike rounded structures, but become flattened towards the end. After some time, the colour changes to reddish-brown. The fruit body is usually found growing at the base of diseased-dead tree or decaying stump. The upper surface of the fruit body bracket is orange-yellow, while the underside is reddish or brownish in colour *(Figure 8.1a).* This disease is very common in young rubber. It is the most serious of the three as it spreads very fast.

Red root disease. The name of the causal fungus is *Ganoderma philippi.* The fungus is in the form of mycelium skin covering the root surface. Soil adheres to the root and only after washing away the soil can the red mycelium be visible. As usual, the fruit body grows at the base of diseased-dead plants or decaying stumps. The upper surface of the bracket is dark red, while the underside ash grey in colour *(Figure 8.1b).*

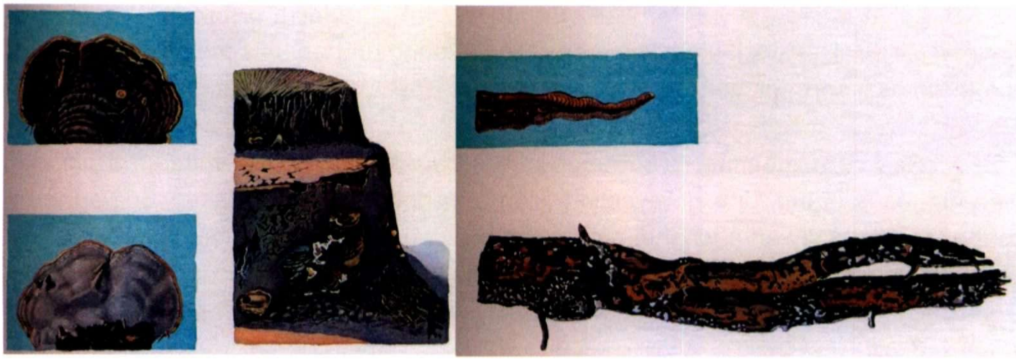
Brown root disease. The causal fungus is the species known as *Phellinus noxius*. The nature of the fungus is just like the red root disease; only the colour is brown which darkens with age. Soil also sticks to the infected root. The root surface becomes rough. When it is split open, brownish zig-zag lines can be seen in the wood tissues. When the rot is at an advanced stage, the wood becomes friable, light and dry, penetrated with sheets of fungal material, forming a honeycomb structure. The fruit body is a hard but smaller bracket with dark brown colour on the upper surface and grey on the underside *(Figure 8.1c)*. This disease is not so common and usually infects old rubber trees.



(a) White root disease



(b) Red root disease



(c) Brown root disease

Figure 8.1 Major root diseases

Prevention of Root Diseases

Treating trees infected by root diseases is very difficult and expensive. Therefore, it is important to prevent them. Before an old rubber area is cleared for replanting, all root disease sources must be removed and burnt. The sources can be located from vacant patches or vacant planting points resulting from dead trees. Clearing methods such as uprooting and poisoning of old trees have been found to reduce root disease incidence in replantings. Even if the trees are manually felled by cutting, the stumps must be poisoned and the cut surfaces painted with creosote. All these will deprive the root disease fungi of food sources. Establishing and maintaining pure legume cover crops can also reduce root diseases as they cause roots and stumps to rot faster. During transplanting of rubber, 226 g of powdered sulphur should be incorporated into the planting hole. Sulphur is known to promote the growth of fungi which are antagonistic to the root disease fungi. Painting of collar protectant chemicals to the collar region of the plant can also prevent root disease infection for two years. As the trees grow, there are bound to be damages caused to the tissues from time to time. Such open wounds on any part of the tree should not be left untreated. Suitable fungicidal wound dressing should be applied immediately. This is because root disease spores can enter the tree through such wounds. An isolation trench is dug between the infected and healthy trees to prevent spread.

Method of Treatment

The infected tree must first be located and identified. This can be done by foliage inspection at three-monthly intervals, beginning from six-month old plants. Trees with unhealthy and deformed leaves should be suspected as root-diseased. This is confirmed by collar inspection. The collar region of the infected plant is exposed by digging a cavity around the base of the plant; the depth of opening should be about 5 cm for a year old to about 20 cm for a four-year old plant. A sharp flat-ended hardwood is used for this purpose to prevent unnecessary damage to the roots. When a diseased tree is found, the neighbouring trees in the row must also be collar-inspected, although they may have been passed during foliage inspection. They may have been infected but have not shown symptoms on the leaves. This procedure is continued along the row until a disease-free tree is found.

On the infected tree, part of the root system is exposed. The size of the exposure can be from 30 cm for a one-year old plant to 60 cm for a four-year old one, while the depth is 20-45 centimetres. All dead roots are removed including the dead portion of the tap root and the debris collected and burnt. Any soil found attached to the roots must be removed. When the root surfaces have dried, suitable collar protectant is painted over the exposed tap root and 15 cm of the lateral roots *(Figure 8.2)*. For white root disease use *Shell Collar Protectant*, while for red and brown root diseases use *Calixin Collar Protectant*. The hole is then refilled by digging the soil from the sides. This is to ensure that no diseased roots are left behind to cause reinfection later on. The treated tree is marked with the name of the disease and the date of treatment. Trees that are collar-inspected and found to be uninfected should also be painted with the protectant. The treated tree is reinspected after two years.

Figure 8.2 Applying collar protectant to diseased roots

Treatment of White Root Disease by Chemical Drenching

Plants infected by white root disease in their initial stages can be treated by drenching the collar region with fungicides such as *Bayleton 25WP* (10 g + 1 litre water). Procedure of locating the trees and identifying the disease is the same as described earlier. The collar region of the infected tree is exposed, the size of the cavity being 20 cm wide and 5 cm deep *(Figure 8.3)*. One litre of the diluted fungicide is poured into it. The cavity is then refilled with soil. It must be emphasized that this method of treatment is only effective where the infection is at the initial stage, that is, before the fungus penetrates into the wood tissues of the root.

(a) Opening up the collar (b) Pouring in the fungicide

Figure 8.3 Treating white root diseased-tree by chemical drenching

Control of Root Diseases in Mature Rubber Area

The aim of controlling root diseases described earlier is to remove their sources when the trees are still young, so that the remaining trees will not be infected with the disease when they mature. However, infection can occur from other sources. Therefore, preparations must be made towards their control. The principle of root disease control in mature rubber is the same as for immature rubber. Tappers normally know the locations of the diseased trees and this simplifies work of locating them. Treatment of diseased tree is aimed at preventing the spread of the disease. But, as the trees grow older, the cost of treatment also increases and the time will come when the infected trees are left to their fate and isolated by trenches, so that the diseases do not spread to other trees. Details of the isolation trench are given in the following paragraph.

Isolation Trench

A trench of 30 cm wide and 60 cm deep is dug all round the infected tree at half the distances of the neighbouring healthy trees. All roots found crossing the trench are pruned off and the debris collected and burnt. The trench is then refilled with loose soil to two-thirds its depth. The trench is reopened yearly and any roots found crossing the trench are pruned off and the debris collected and burnt. This procedure is repeated several times until the fungus on the infected tree becomes inactive, thus depleting food source to the root disease fungus. This will only take place when the infected tree rots. Proper siting of the isolation trench is very important, as it is essential to ensure that there are no diseased trees outside the isolated area. The procedure is to inspect the collars of trees around the infected one until a healthy tree is found and to site the trench between the healthy and the diseased trees. When constructing an isolation trench, all roots found must be carefully inspected. If diseased roots are found, the position of the trench may have to be shifted much further *(Figures 8.4 and 8.5)*.

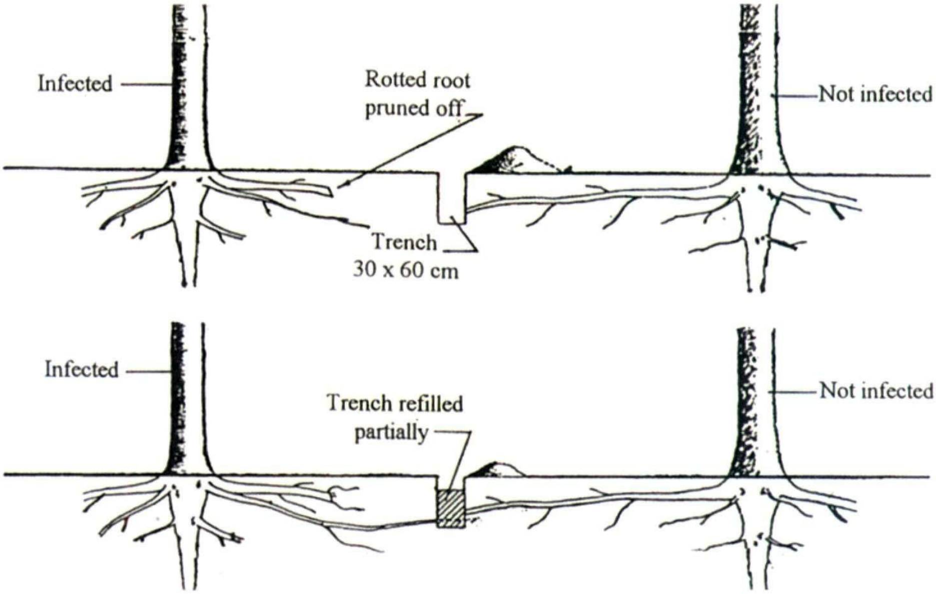


Figure 8.4 Cross-section of isolation trench

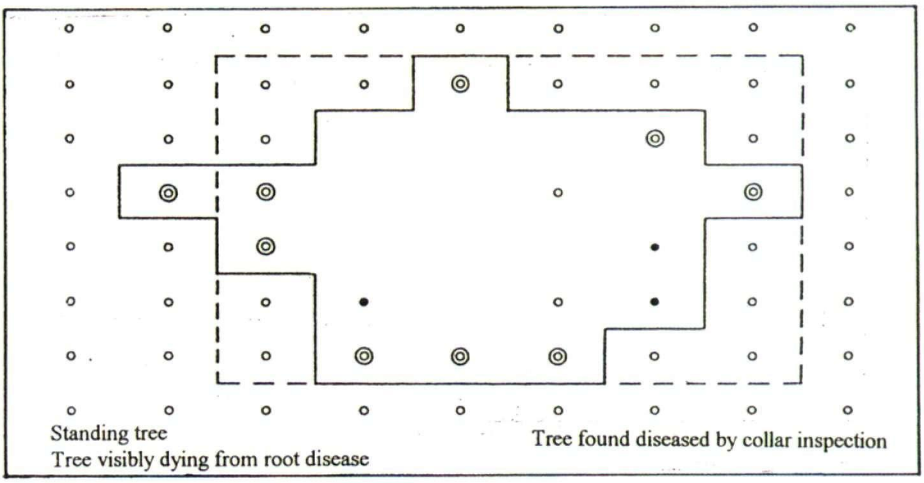
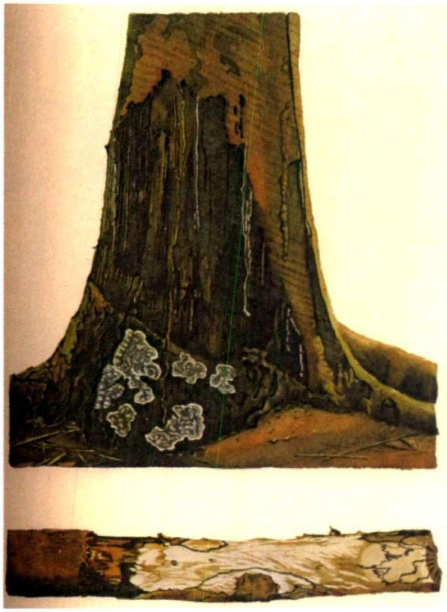


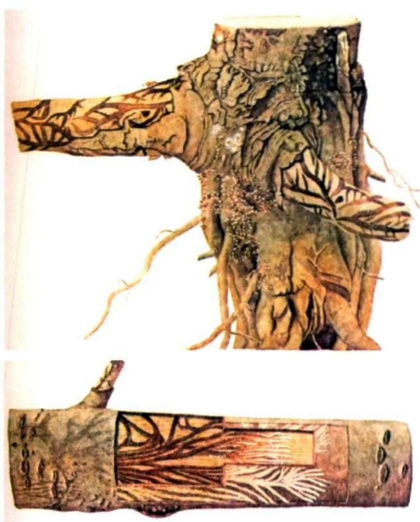
Figure 8.5 Plan of root disease patch isolation

Other Root Diseases

Besides the three major root diseases described earlier, there are three other minor ones which infect the rubber trees. They are *Ustulina* root rot, *Poria* root rot and stinking root rot *(Figure 8.6)*.



(a) *Ustulina* root rot



(b) *Poria* root rot

(c) Stinking root rot

Figure 8.6 Minor root diseases

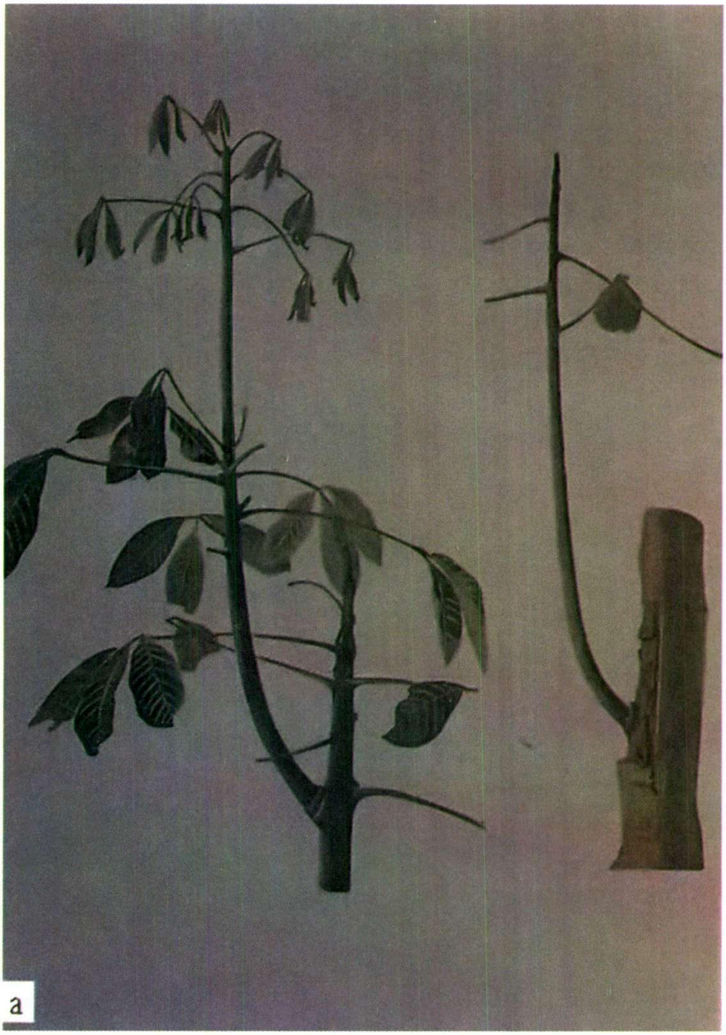
Ustulina root rot, which is caused by *Ustulina deusta* can be controlled by pruning off any part of the roots that are penetrated by the fungus and the resultant wounds treated with suitable fungicidal wound dressing. For *Poria* root rot, caused by *Poria hypobrunnea*, the rotted roots are also pruned off and the resultant wounds treated with the same dressing. If the infected roots are still alive, the disease can be controlled by just scraping off the fungus. For stinking root rot, which is caused by *Sphaerostilbe repens,* the infected plants are removed together with the root system and burnt. At the same time, the drainage system in the area must be improved.

STEM DISEASES

The rubber tree stem, which includes branch, fork and tapping panel, is also subject to disease infection. Pathogenic dieback, pink disease, mistletoe, *Ustulina* stem rot, *Phellinus* stem rot, bark necrosis, mouldy rot, black stripe, panel necrosis and brown bast are some of the serious ones. Their causes, symptoms and treatments are briefly described below.

Pathogenic Dieback

This disease which is caused by the fungus *Colletotrichum gloeosporioides* infects leaves and stems of young scion shoot terminals. The terminal leaves turn brown and fall. The stem dies up to the budpatch *(Figure 8.7a).* Such plants are removed and replaced. Stems of plants that suffer partial dieback, should be pruned off up to healthy tissues and the resultant wounds treated with suitable fungicidal wound dressing mentioned earlier.



(a) Phatogenic die-back

Figure 8.7 Types of Stem Disease

Pink Disease

Pink disease infects the branch and the fork of rubber tree of three to eight years old. It spreads during wet weather. The causal fungus is *Corticium salmonicolor* and the spores are spread by air current. Clones RRIM 600, RRIM 701, RRIM 729, RRIM 901, RRIM 905, PB 255 and PB 28/59 are found to be susceptible to this disease. Its early symptom is the appearance of a cobweb-like film of silky white mycelium on the branch, usually near the fork. Later, drops of latex start exuding from it. As the mycelium penetrates the cortical tissues, it becomes more distinct and turns pink in colour. The disease spreads around the branch extending up to a metre and can also cross over the adjacent branch through the fork. More bleeding occurs which later result in open wounds of the bark. The branch dries up with black streaks of coagulated latex on it. Several side shoots from dormant buds appear just below it *(Figure 8.7b)*. Pink disease can be controlled by fungicide known as *Bordeaux* mixture which is made up of (1 kg copper sulphate + 25 litres water) and (2 kg dehydrated lime + 75 litres water). The fungicide can be sprayed on to the infected branch. It can also be brushed on with the water content in the formulation reduced to 25%. The copper content in the mixture may affect latex properties. Therefore, for mature trees, *Calixin* should be applied neat by brushing or *Daconil F500* at 3 litres in 97 litres water by spraying.

(b) Pink disease

Figure 8.7 Types of Stem Disease

Mistletoes

Mistletoes are semi-parasitic plants growing on other plants such as rubber. They have their own leaves and are therefore able to prepare carbohydrates themselves, and are not fully dependent on their hosts for food. Two species are commonly found in Malaysia, namely *Loranthus globasus (Figure 8.7c)* and *Loranthus pentandrus.* Mistletoes are connected to the host plant by suckers that penetrate deep into the wood. The affected shoot beyond where the mistletoe is attached gradually becomes weak, leafless and dies. The infected host branch is pruned off and the resultant wound is treated with suitable wound dressing. This operation is best carried out during the wintering season, when the mistletoe is easily seen.

(c) Mistletoe

Figure 8.7 Types of Stem Disease

Ustulina Stem Rot

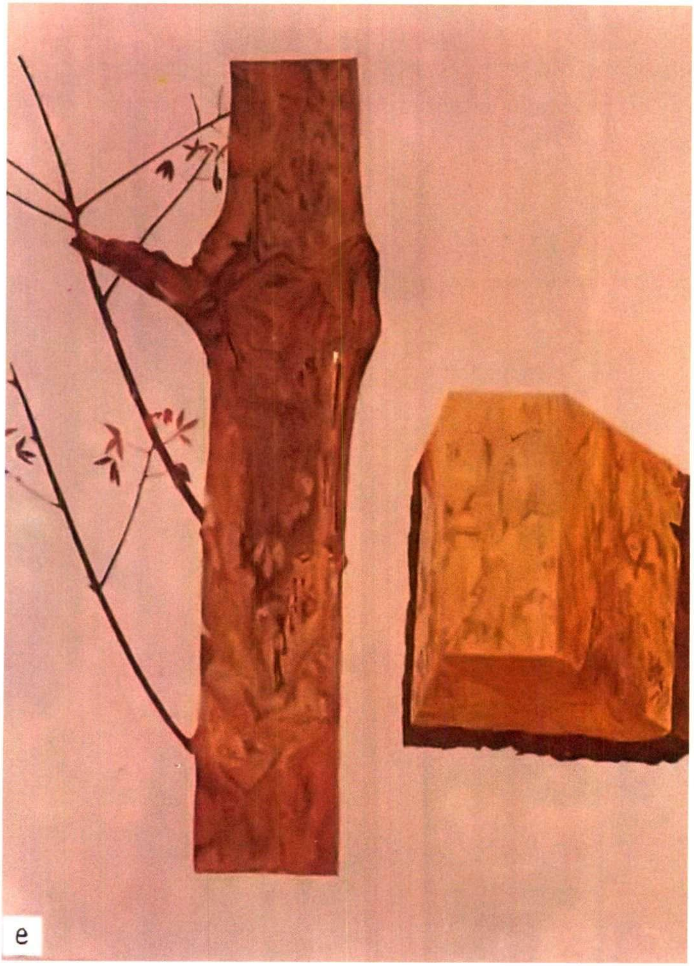
This disease can infect any part of the stem that has open wounds, cracks in the fork, broken ends of large branches and even wounds caused by deeply inserted spouts and latex cup hangers, through which the fungus can enter. The causal fungus is *Ustulina deusta*. The early symptoms can be bleeding of latex from any part of the stem or large branch, followed by its coagulation resulting in foul-smelling pad beneath the rotted bark. Fructifications soon develop on the stem as velvety, greyish-white, flat plates. They later turn grey-black or charcoal or grow into a contiguous sheet covering a large portion of the wound. This is often followed by borer beetle invasion. The fungus can penetrate deep across, causing the stem to snap off (*Figure 8.7d*). The diseased tissue is completely pruned off to a healthy portion and fungicidal wound dressing is applied over it. This disease can be easily prevented. Any physical damage to the tree must be attended to immediately. Latex spout should not be fixed too deep so that it does not touch the wood. Only cup hangers with springs should be used.

(d) *Ustulina* stem rot

Figure 8.7 Types of Stem Disease

Phellinus Stem Rot

Phellinus stem rot attacks mature rubber, the causal fungus being *Phillinux noxius*. It infects exposed cut surfaces of stumps, broken ends or branches and any other exposed tissue of damaged trees. The rot finally goes down to the roots causing brown root disease. The rotted wood is dry and penetrated with plates of brown mycelium which gives it the honeycomb-like appearance as in the case of brown root disease described earlier *(Figure 8.7e)*. The diseased part should be pruned off to a healthy tissue and the wound treated with creosote. This disease can be prevented by giving immediate attention to any wounds occurring on the tree either by accidental damage or scheduled pruning.



(e) *Phellinus* stem rot

Figure 8.7 Types of Stem Disease

Bark Necrosis

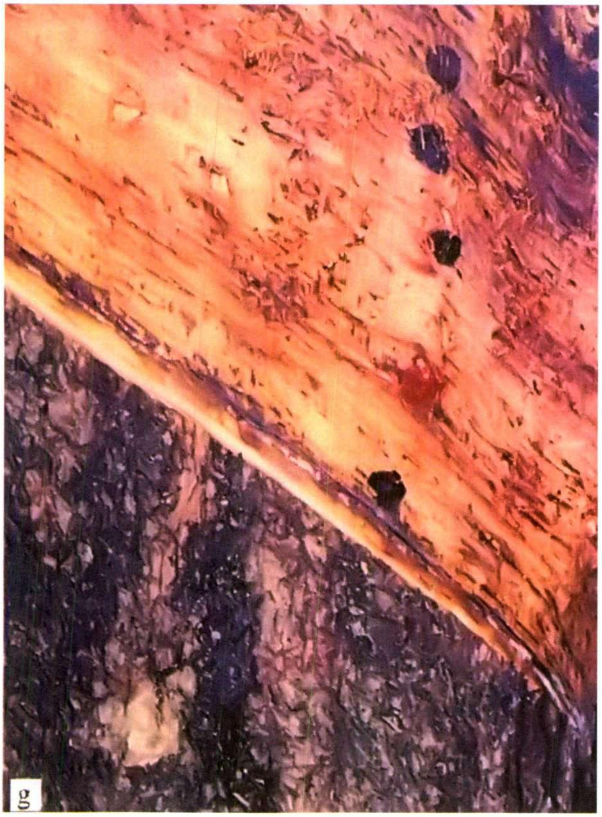
This disease infects the bark of the rubber tree, and clones PB 28/59, PB 28/83, PB 5/51, GT 1, PR 107 and RRIM 605 are found to be susceptible to it. The causal fungus has not yet been identified. It spreads during wet season. The lower part of the stem below the tapping cut is infected the most. The disease starts as brownish necrotic spots on the tapping cut, which may extend to the renewed bark in patches. The disease may also start from the top, from cracks in the stem above the tapping panel. In fact, it can start from any part of the tree, from the fork right down to the collar (*Figure 8.7f*). When the outer bark is scraped off, the disease is seen spreading into the cortex as purplish-red or reddish-brown patch of moist tissue. During dry weather, the dead cortex drops off, the bark regenerates and the tree recovers. But if the wet season is prolonged, the cambium is affected, resulting in excessive bleeding of latex with large wounds. Borer beetles may attack and the tree eventually dies. The infected area on the tree is treated by weekly spraying or brushing with fungicide such as *Difolatan* at 2%. The infected tree should not be tapped for six months.

(f) Bark necrosis

Figure 8.7 Types of Stem Disease

Mouldy Rot

Mouldy rot infects the tapping panel. The causal fungus is known as *Ceratocystis fimbriata*. The susceptible clones are RRIM 600, RRIM 605, RRIM 501 and PR 107. The symptoms are depressed discoloured spots just above the tapping cut which later darken and become covered with greyish mould. As the infection spreads, an irregular band of infection is formed running parallel to the tapping cut. If not treated, patches of exposed areas can develop resulting in large tapping wounds *(Figure 8.7g)*. Spores of the fungus are mostly spread by the tapping knives. The disease can be treated by fungicides such as *Benlate* at 0.5% or *Difolatan* at 2%. The fungicide is sprayed or brushed on to the infected panel at weekly intervals. The disease can be prevented by having free circulation of air in the plantation. Height of weeds should always be kept lower than 60 cm and the tapping knives should be regularly disinfected, especially during wet weather.

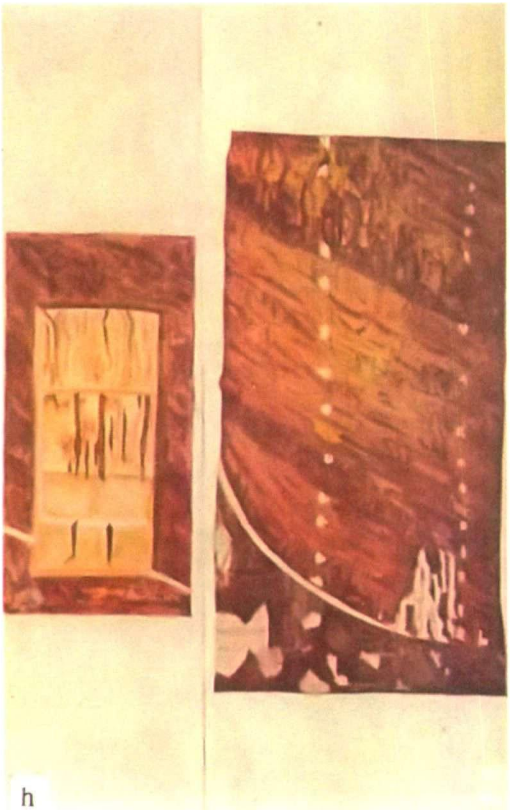


(g) Mouldy Rot

Figure 8.7 Types of Stem Disease

Black Stripe

Black stripe is also a disease of the tapping panel. It is caused by the fungus *Phytophthora palmivora*. The disease can spread from tree to tree through the tapping knife. Clones AVROS 2037, RRIM 600, RRIM 605, RRIM 607 and RRIM 623 are susceptible to it. The symptoms are a series of sunken and discoloured areas just above the tapping cut, and later, vertical dark fissures are seen at the same place. The stripe widens and coalesces into a broad lesion which may cover the full length of the panel. When the bark is scraped, the underlying tissues become discoloured brown or black and narrow vertical lines on the surface of the wood (*Figure 8.7h*). The panel can be treated by spraying or brushing with fungicide, such as *Difolatan* at 2% or *Ridomil 25WP* at 0.8% three times per week. There are also other effective chemicals, such as *Sandofan M, Fruvit* and *Caltan*. The tapping knife must also be disinfected in the fungicide. The infected trees should not be tapped until the rainy season is over.

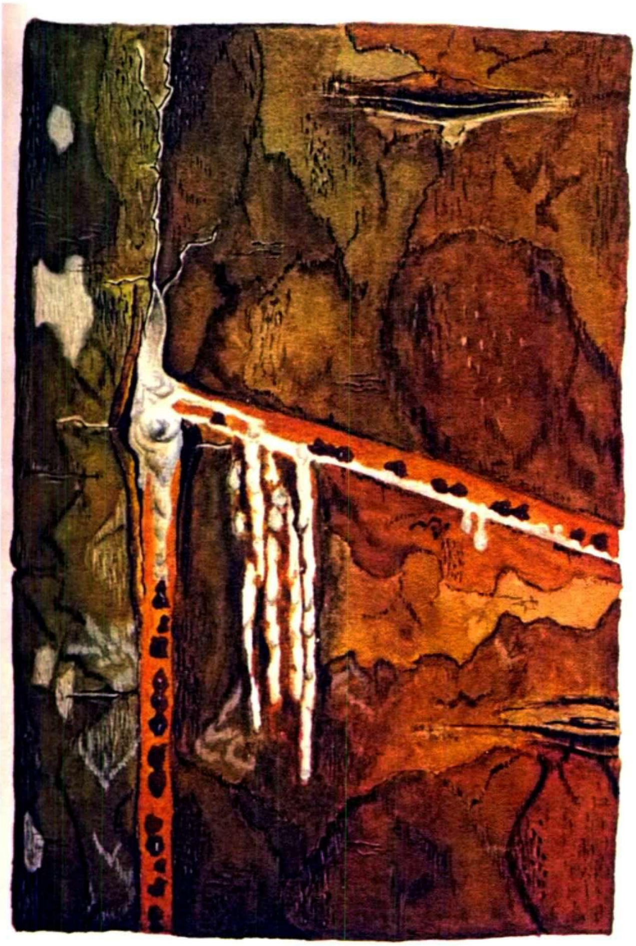


(h) Black stripe

Figure 8.7 Types of Stem Disease

Panel Necrosis

This disease, caused by *Fusarium solani*, infects newly opened tapping panel. It spreads during wet weather. The susceptible clones are PB 5/51, PB 28/59, PB 28/83, PR 107, RRIM 605, RRIM 612, RRIM 623 and RRIM 628. The disease infects the tapping and the panel boundary cuts. Slightly sunken lesions sometimes coalescing into a long chain, develop on the bark in the intermediate region of the panel guide markings. If the cambium and xylem are infected, the bark decays and splits open (*Figure 8.7i*). The infected tree can be treated by spraying or brushing with fungicide such as *Difolatan* at 2% each time after tapping for four to five days. Avoid opening of new tapping panel during wet weather.



(i) Panel necrosis.

Figure 8.7 Types of Stem Disease

Brown Bast

Brown bast (or tree dryness) is not yet considered a disease as it is not connected with any pathogen. It is a physiological disorder of the latex vessels in that no latex is produced when the bark is tapped away. Almost all clonal seedling materials and some of the high-yielding clones are susceptible to brown bast. Symptoms of trees that suffer from brown bast can be several, beginning from partial dryness of the tapping cut to total dryness of the tree, the most chronic of all being the flaking of the bark (*Figure 8.7j*). There is no known cure for brown bast yet. The most effective method currently available is to stop it from spreading along the latex vessels, by creating a discontinuity between the dry and the yielding areas of the bark. Details of this isolation technique are described below.

(j) Brown bast or tree dryness.

Figure 8.7 Types of Stem Disease

Isolation of pre-tapping panel. Brown bast can be prevented by making pre-tapping isolation grooves, especially on clones susceptible to it. This is done three months before the commencement of tapping. A tapping panel must first be marked out on the tree to determine the position of the back and front panel boundary lines. Using a specially modified discarded tapping knife, a vertical cut to the wood is made along the back panel boundary channel and along the budding union or just above ground level (for a deep-planted tree) in the shape of a reversed letter L. This results in the physical discontinuity in latex vessels between the two lower panels. This is to ensure that if dryness develops on panel BO-1, it will be confined to this panel, without spreading to panel BO-2.

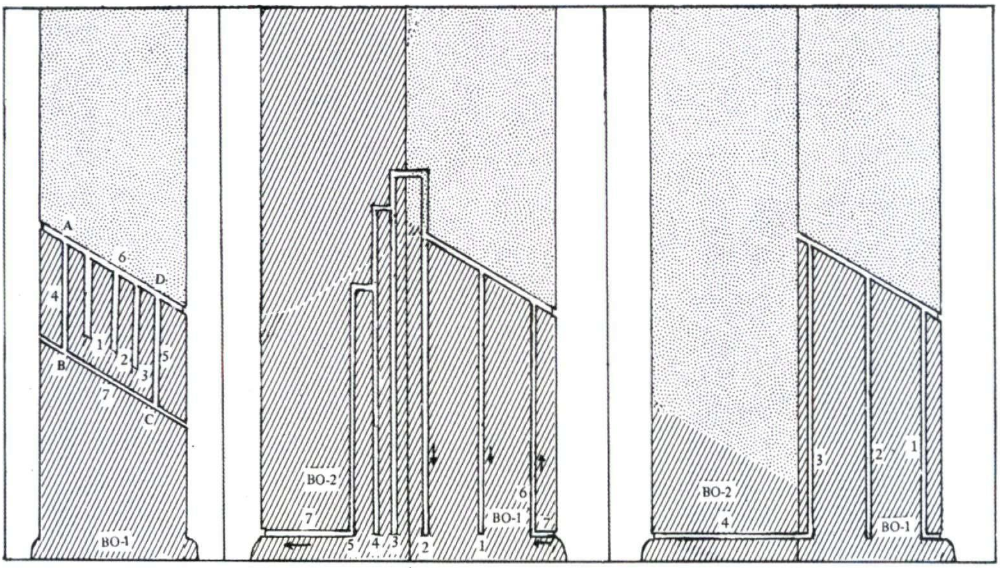
Trees with partial dryness of the tapping cuts. The length of the tapping cut that is dry is marked. A vertical groove up to tapping depth is made extending below the tapping cut. The groove is continued until the yielding bark. Similar additional vertical grooves (1, 2, and 3) are made at 2 cm intervals to the right of the first vertical groove (*Figure 8.8a*). This is repeated till yielding bark is encountered as indicated by the presence of latex in test grooves 4 and 5. From this it is clear that dryness is only confined to the area ABCD (*Figure 8.8a*). A deep cut to the wood is made along ABCD to isolate it. Tapping is resumed along BC.

Total dryness on panel BO-1. The whole tapping cut is dry. Two vertical cuts of tapping depth 1 and 2 are made downward to determine ten extent of dryness (*Figure 8.8b*). If it is proved from test cut 2 that dryness has spread beyond the left or panel BO-1 and into panel BO-2, test cuts 3, 4 and 5 are made upward from the union to determine the spread. A sixth test cut is then made on the right of BO-1, and if this shows that there is no dryness there, a horizontal cut 7 along the budding union below panel BO-2 is then made to prevent the upward spread of dryness form the roots. Tapping can resume by opening panel BO-2.

Total dryness on panel BO-2. If there is complete dryness on panel BO-2, it is usually confined to that panel only. Vertical test cuts 1, 2 and 3 are made to find out the extent of dryness (*Figure 8.8c*). If it is proved that dryness has spread into the roots, a horizontal cut 4 is made to prevent the upward spread of dryness into panel BI-1 from the roots (*Figure 8.8c*). Tapping can resume on panel BI-1 if the renewed bark is thick enough for retapping; otherwise resume tapping on virgin bark above it.

Total dryness on both the lower panels. For trees with total dryness on both the lower panels (BO-1 and BI-2), the virgin bark above them can be exploited by upward tapping.

Re-exploitation of dry bark. If the isolated dry bark is to be retapped later on, it must be removed by scraping. The depth of scraping is to remove the brownish discoloured bark to maximum of tapping depth. This is to allow new bark to regenerate with fresh latex vessels formed. The regenerated bark can be retapped when it is sufficiently thick.



a b c

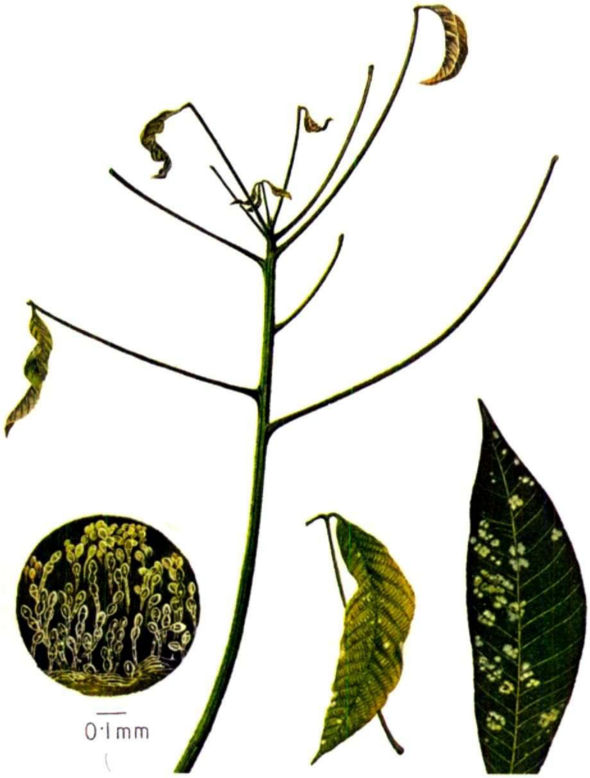
(a) Partial dryness on panel BO-1 (b) Total dryness on panel BO-1 (c) Total dryness on Panel BO-2
Figure 8.8 Controlling brown bast or tree dryness

LEAF DISEASES

Rubber plants suffer from several leaf diseases which affect the well being of the plants. The most common leaf diseases in the nursery are Bird's Eye Spot and *Colletotrichum* leaf disease while on mature rubber, secondary leaf fall caused by *Oidium heveae* and *Colletotrichum gloeosporioides* are the most important leaf diseases followed by *Phytophthora* abnormal leaf fall, *Corynespora* Leaf Fall and *Fusicoccum* Leaf Blight. Their brief descriptions are given below.

Oidium Secondary Leaf Fall

This disease is also known as powdery mildew and caused by the fungus *Oidium heveae.* It infects mostly young shoots that refoliate after wintering. The presence of numerous leaflets on the ground is the sign of an attack. Unfolding leaflets of up to 5 cm in length are shrivelled and progressively blackened from the leaf tip and fall, leaving the petioles attached to the branch for a while *(Figure 8.9a)*. If the tree is shaken, a shower of leaflets will fall. Clones PB 217, PB 235, PB 255, PB 260, PB 28/59, PB 280, PR 255, PR 261, RRIM 701, RRIM 728, RRIM 901 and RRIM 905 are susceptible to this disease.



a) Oidium or powdery mildew

Figure 8.9 Type of Leaf Diseases

This disease can be controlled by dusting the leaves with sulphur throughout the refoliating season at five to six weekly rounds. Fogging with fungicide tridemorph such as *Calixin 75 EC* at 0.5 a.i/ha also provides a good control of the disease. It is recommended to avoid planting of susceptible clones in areas prone to the disease.

Colletotrichum Secondary Leaf Fall

This disease is caused by fungus known as *Colletotrichum gloeosporioides.* Leaves are most susceptible during the period of budburst and for about ten days thereafter. In older leaves, the leaf margins, particularly the tips, are shrivelled, but they are covered with small spots with narrow brown margins surrounded by yellow halos a millimetre or more in width. As the leaves become older, the spots become slightly raised *(Figure 8.9b)*. This disease may also cause dieback of green shoots. Susceptible clones are PB 28/59, PB 235, PB 255, PM 10, BPM 24, RRIM 712, RRIM 728, RRIM 937, RRIM 2005 and RRIM 2026.

b) Collectotrichum disease

Figure 8.9 Type of Leaf Diseases

Satisfactory control of this disease in the nurseries or shorter immature planting can be achieved using fungicide chlorothalonil and propineb such as *Daconil* and *Antracol* respectively at 0.2% in water using a knapsack sprayer or a back-pack power mist blower. Chemical treatment for mature rubber is not economical, except for very severe outbreak. It is recommended to avoid planting of susceptible clones in areas prone to the disease.

Phytophthora Abnormal Leaf Fall

This disease is caused by the fungus known as *Phytophthora botryosa and P. palmivora*. However, the fungus, *Phytophthora botryosa* is more commonly observed from the *Phytophthora* leaf fall areas. The infected leaves are often shed with their three leaflets attached to the petiole where one or more black lesions with white spots of coagulated latex in the middle can be observed. Infected pods become blackened, malformed and unopened, but remain on the tree with the seeds inside shrivelled and rotten *(Figure 8.9c)*. Infection on terminal twigs usually leads to dieback of green shoots. The susceptible clones are RRIM 600, PB 217, RRIM 623, RRIM 905, RRIM 936, PB 255, PB 28/59 and PM 10.

c) *Phytophthora* leaf fall

Figure 8.9 Type of Leaf Diseases

This disease can be controlled by spraying with fungicide copper oxychloride in oil (1.2 kg a.i/ha) using a mist blower about four weeks before the onset of rainy season. Avoid planting susceptible clones in areas prone to the disease is recommended.

Corynespora Leaf Disease

The disease is caused by a fungus known as *Corynespora cassiicola*. It infects both young and old leaves, particularly along the veins. Initially, it appears as a greyish dark spots which enlarges into circular or irregular papery lesions, surrounded with yellow halo ranging from 1-8 mm in diameter and dark grey in colour. The veins are discoloured, giving the characteristic fish-bone appearance. The leaves turn yellow and later drop *(Figure 8.9d)*. One lesion is enough to cause defoliation, especially, if it is sited on the main vein. Clone RRIM 600 is severely infected by the disease.

d) Corynespora Leaf Disease

Figure 8.9 Type of Leaf Diseases

Satisfactory control of *Corynespora* leaf disease can be obtained by spraying with fungicide benomyl such as *Benlate* at 0.3%.

Bird's Eye Spot

This disease is caused by the fungus known as *Bipolaris heveae.* This fungus mainly attacks poorly growing nursery seedlings. The infection causes refoliation and retards the plant growth. Infection on older leaves causes only small dark specks while on leaves at fully-green stage, yellow halos are observed around the shot holes *(Figure 8.9e)*. Younger leaves shrivel before falling off. It can be controlled by weekly spraying of fungicides propineb and mancozeb such as *Antracol* and *Dithane M-45* respectively at 0.2%. At the same time the seedlings must be given adequate manuring.

e) Bird's eye spot leaf disease

Figure 8.9 Type of Leaf Diseases

Fusicoccum Leaf Blight

Fusicoccum leaf blight, which is caused by a fungus of the *Fusicoccum sp.*, was first reported in 1987. Among the susceptible clones are RRIM 600, RRIM 2023, RRIM 2024 and RRIM 2025. The symptoms are most prominent on expanded leaves. The lesions resemble those of anthracnose described earlier but they are larger with concentric brownish zones which stand out against the uninfected area. Initial infections appear as rusty-brown pin-head size spots which later become large. Lesions are most common at leaf tips and margins. Within lesions numerous dark pustules barely recognizable to the naked eyes, are found and are abundant on the upper leaf surface. Infected leaves gradually turn bronze in colour before abscission *(Figure 8.9f)*. Laboratory evaluation showed that fungicides propiconazole, carbendazim, prochloraz and penconazole are effective against the fungus.

f) *Fusicoccum* Leaf Blight

Figure 8.9 Type of Leaf Diseases

PHYSICAL INJURIES

Rubber trees also suffer from injuries. There are several among them that need attention. The following describe briefly the important injuries and their treatments.

Flooding and Water-logging

Excess water in the soil surrounding the planted crops can cause breathing difficulties to their roots. This can retard growth. The leaves turn yellow-green or total yellow. The lenticels of smaller plants become swollen *(Figure 8.10a).* Prolonged flooding can kill smaller plants, while on older trees, it can cause the bark to crack and ooze out latex, which later turns to pads of coagulum beneath it. This is usually followed by borer beetles attack which finally kills the tree. The roots may later be infected by stinking root rot *(Sphaerostilbe repens).* Its remedy is to remove excess water from the affected area by contructing efficient drainage system.

(a) Flooding and water-logging

Figure 8.10 Type of Physical Injuries

Drought

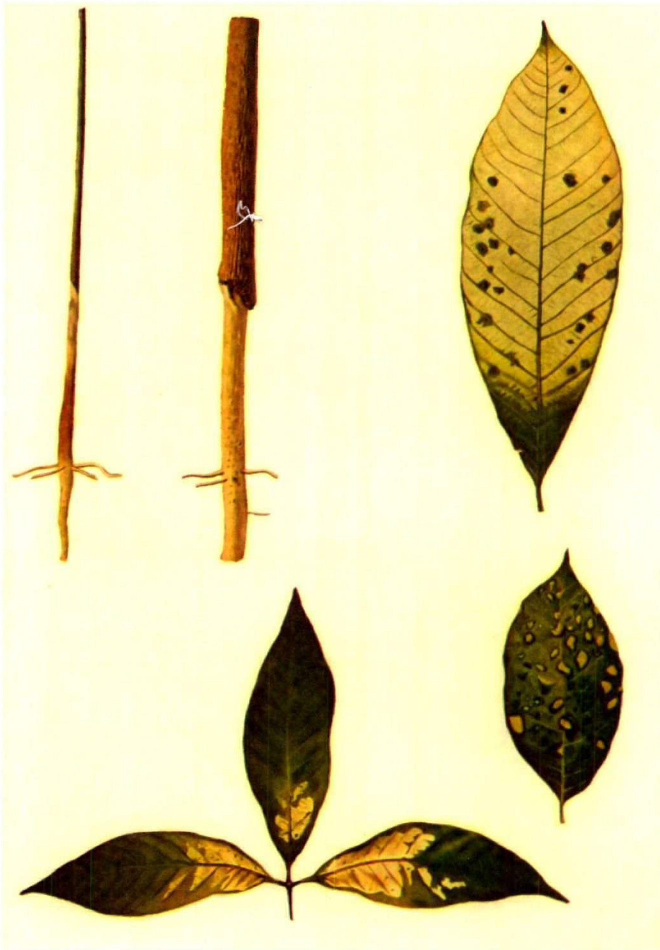
Plants need water for their general growth. Due to the nature of their structure, sandy soils are unable to retain water, thus causing stress to planted crops during drought. Drought causes the leaves of young plants to wilt, shrivel and finally die. The green stems are also affected and this is followed by dieback. Prolonged drought can also affect older plants *(Figure 8.10b)*. Newly wilted plants can recover if watered immediately. Stems of plants that have suffered dieback are pruned off to healthy tissues. Field transplanting should be avoided during dry season.

(b) Drought

Figure 8.10 Type of Physical Injuries

Sunscorch

Although plants generally need sunlight for their growth, excessive heat from it can cause radiation. As a result the leaves are bleached, severely wrinkled and die. Stems of young plants are also affected, in which the bark around the base gets killed. This usually happens on sandy soil and where there is no ground cover crops *(Figure 8.10c)*. The renewing bark on the tapping panel can get scorched too by direct intense sunlight. Newly transplanted materials must be mulched. When transplanting advance-aged planting materials, the stems should be lime-washed to enable them to reflect sunlight. Plants already affected by sunscorch should be removed and replaced.



(c) Sunscorch

Figure 8.10 Type of Physical Injuries

Fire Damage

Damage by fire is quite a common incident in rubber cultivation, especially during the wintering season, as the condition is dry and there are a lot of dry leaves on the ground. The cause of the fire is mostly accidental. Young plants can be killed outright. Leaves of older trees become scorched, turn brown and eventually fall. The affected bark bleeds, and later is invaded by borer beetles which eventually kill the tree *(Figure 8.10d)*. Trees affected by fire damage must be immediately (before the borer beetles come in) white-washed with a mixture of 500 g dehydrated lime in 1 litre of water and 2 ml insecticide such as *Mitac 20*. This is to reduce the radiation effect of sunlight on the already scorched bark and at the same time keeps away the borer beetles. Later, the affected dead tissues are removed and the resultant wounds treated with suitable wound dressing.

(d) Fire damage

Figure 8.10 Common physical injuries

Lightning Strike

Direct lightning strike can kill the tree instantly, but less severe ones only cause wounds. Lightning usually strikes a group of about half a dozen trees, and on one side of the trees only. If the strike is on the upper part of the tree, green leaves will fall with the petioles attached to the plants. The bark splits and latex oozes out. The bark dies from the cambium outwards and finally peels off *(Figure 8.10e)*. Treatment is the same as for trees damaged by fire.

(e) Lightning

Figure 8.10 Common physical injuries

Poisoning

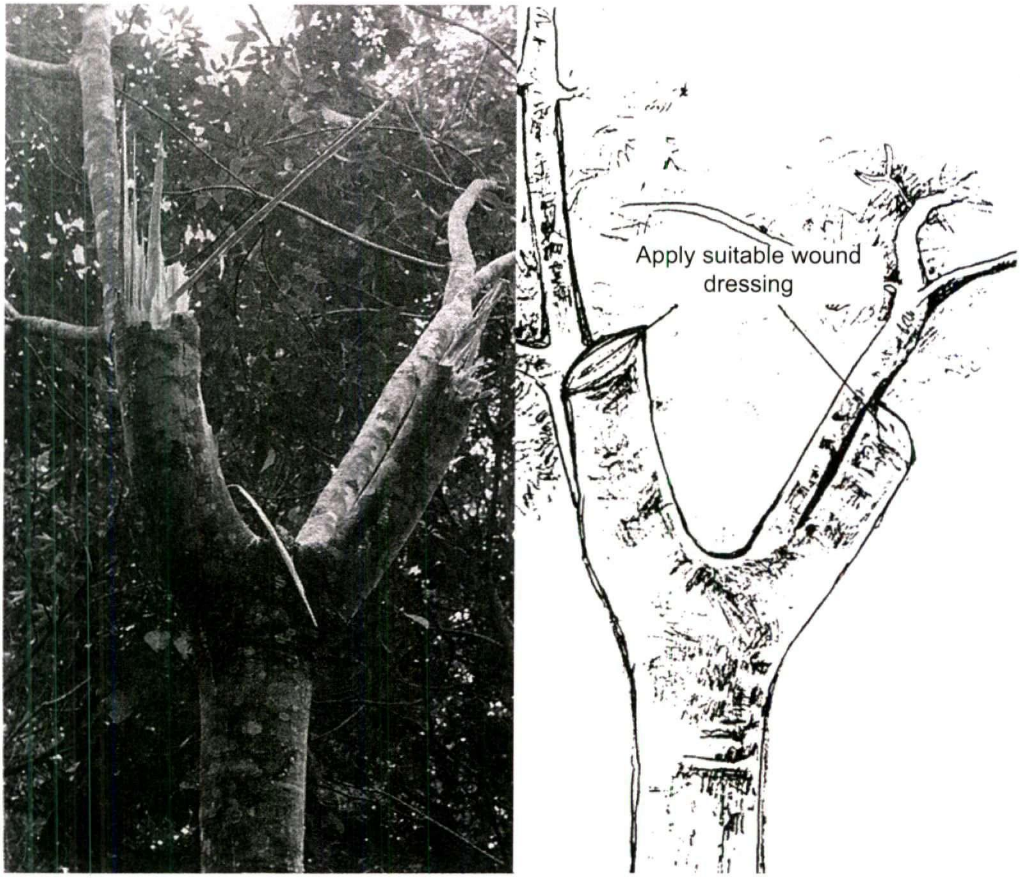
Poisoning of trees usually happens during herbicide spraying, when the spray drifts come into contact with the planted crops such as rubber. Large patches of whitened dead tissues are seen on the leaves which are later invaded by saprophytic fungi, and finally drop. The bark is killed in irregular patches, followed by exudation of latex and invasion by borer beetles. Damage can also be caused by uptake of herbicides spilt on the ground by the roots *(Figure 8.10f)*. Damages by hormone type of herbicides are general in nature, from dieback of the terminal to the roots. All dead tissues are removed and the resultant wounds treated with suitable wound dressing. Preparation of herbicide mixtures should not be done near the planted crops. Spray drifts should not be allowed to get into contact with planted crops. Sprayer shields should be used when spraying is done in areas where the plants are still very young.

(f) Poisoning

Figure 8.10 Common physical injuries

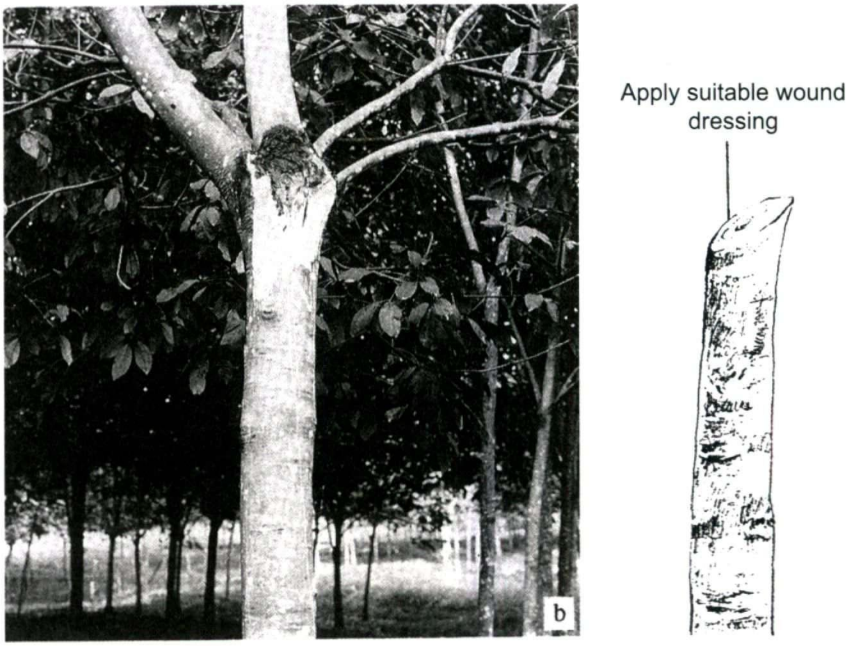
Wind Damage

Rubber trees are also subject to injuries by strong winds. Such damage is common in low-pressure areas of Peninsular Malaysia and on susceptible clones such as RRIM 623, RRIM 701, RRIM 728, RRIM 905, PB 235, PB 254, PB 280, PB 28/59, Nab 17, BPM 24 and RRIC 110. Injured trees must be treated immediately before the dead tissues become extensive and cause other problems such as fungus infection or insect invasion. There are several types of injury resulting from wind damage, namely, branch breakage, branch split, crown snap, trunk snap, trunk split and uprooting *(Figure 8.11).*



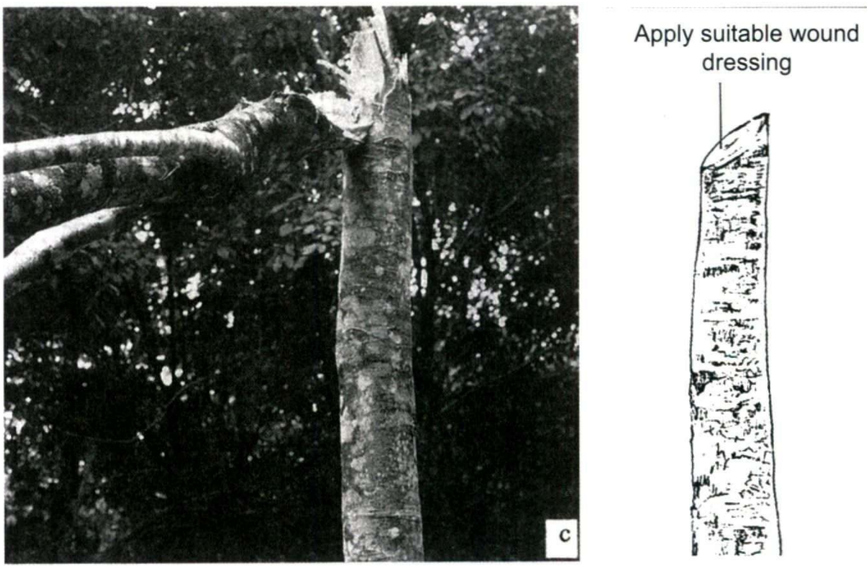
(a) Branch breakage

Figure 8.11 Types of wind damage (left) and their treatments (right)



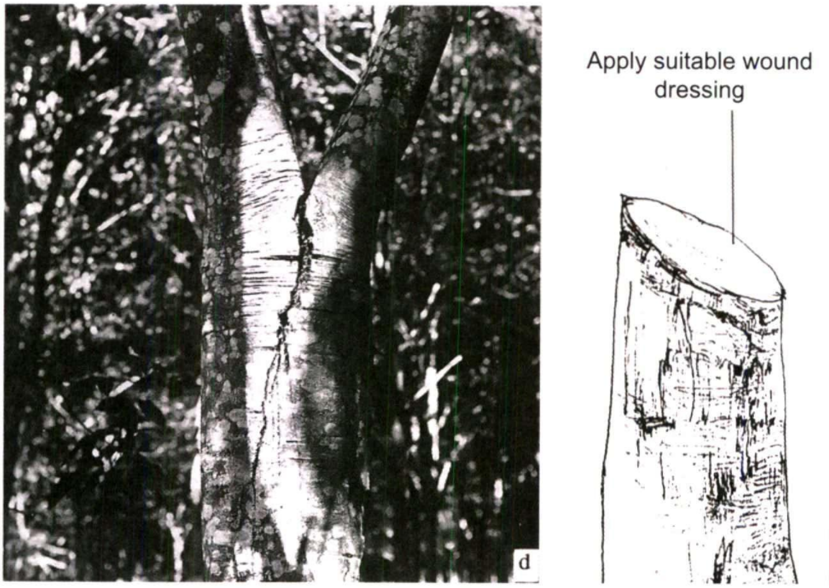
(b) Crown split

Figure 8.11 Types of wind damage (left) and their treatments (right)



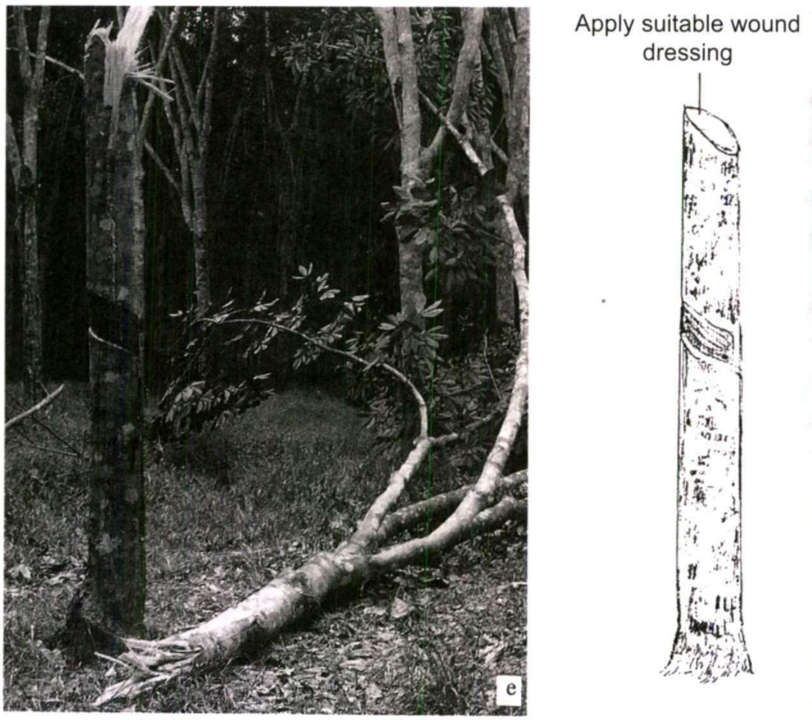
(c) Trunk split

Figure 8.11 Types of wind damage (left) and their treatments (right)



(d) Trunk snap

Figure 8.11 Types of wind damage (left) and their treatments (right)



(e) Crown snap

Figure 8.11 Types of wind damage (left) and their treatments (right)

The injured part of the tree must be pruned off. Pruning must be done by a sharp pruning saw to obtain a clean cut. Ensure that no crack is seen on the cut surface. The cut surface is treated with suitable wound dressing. For the uprooted tree, if a reasonable length of the tap root is still good, its end is neatly pruned off and wound dressing applied. All the branches, including the main ones, are also pruned off and wound dressing applied. The tree is then reinstated. The trunk is immediately lime-washed to prevent scorching of the bark. If the affected tree is in tapping, it must be rested for six months.

PESTS

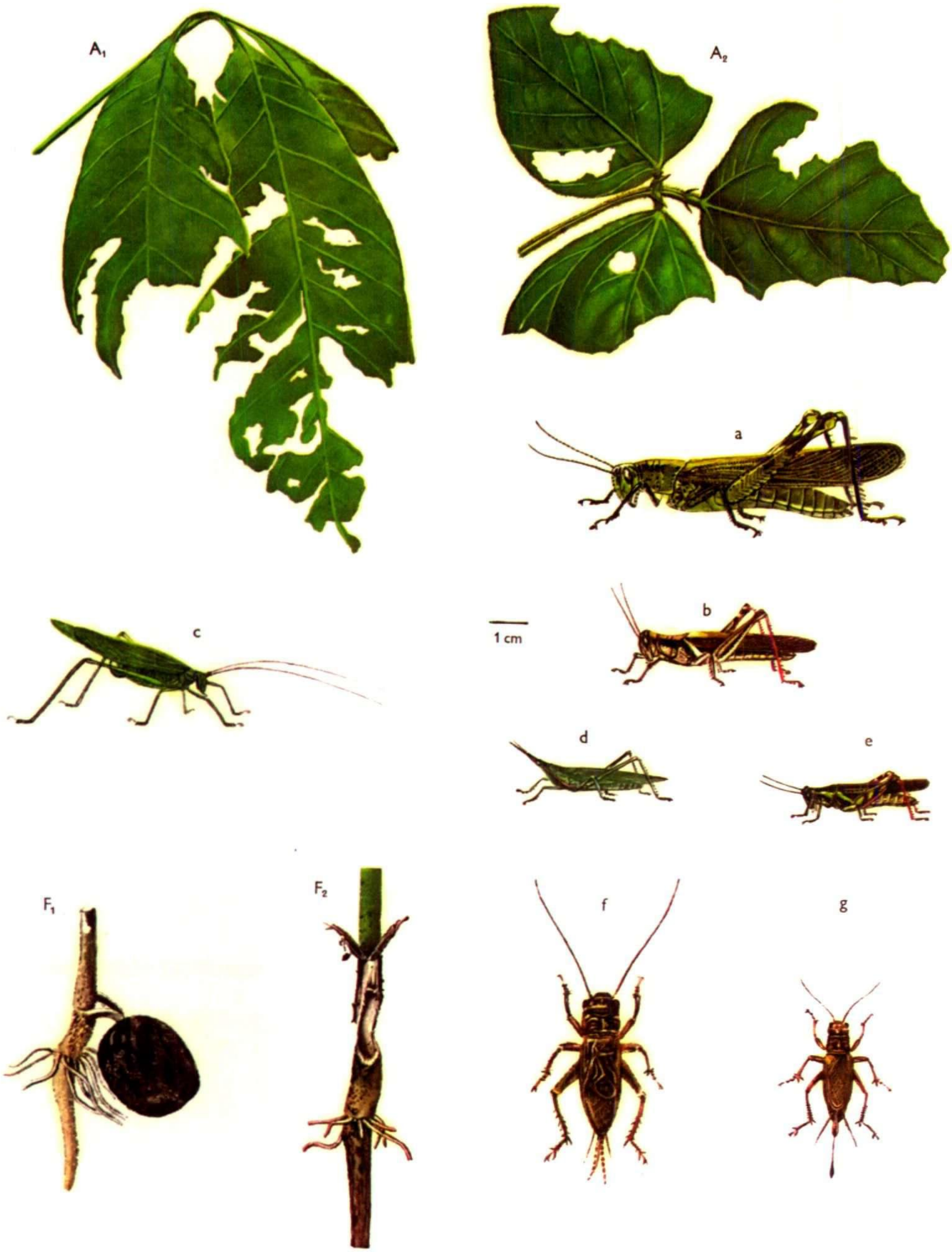
The rubber tree is also subject to attack by animal pests, which are grouped into three – insects, molluscs and mammals. Their brief descriptions, the nature of damage they cause and their control are given in the following paragraphs.

Insects

Insects, which are defined as small animals from the *Insecta* class, are made up of three body parts, namely head, thorax and abdomen, and three pairs of legs. Those causing serious problems to rubber are described below.

Grasshoppers. Grasshoppers eat away the leaves of legume covers leaving only the veins and the young shoots of germinating rubber seedlings. They are active during the day. The species *Valanga nigricornis* is the most destructive. Other common species are *Xenocatantops humilis*, *Stenocatantops splendens* and three other species of *Atractomorpha* (*Figure 8.12a*). They can be controlled by spraying with insecticides such as *Orthene 75S* at 1 g + 1 litre water, *Tamaron 600* at 1 ml + 1 litre water or *Malathion LV* at 1 kg per hectare applied neat by ultra-low volume (ULV) spraying.

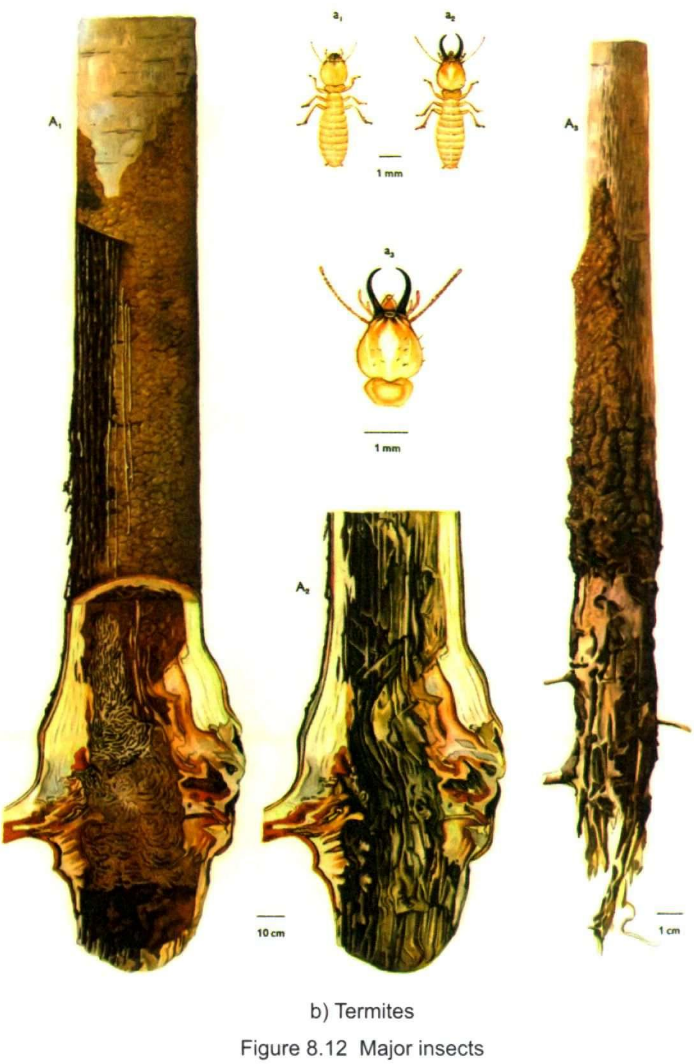
Crickets. The species of *Brachytryptes portentosus* and *Acheta testacea* attack rubber. They are active at night, and eat away from the terminal shoot right down the base of young rubber seedlings including the collar region. *Acheta testacea* eat away the regenerating bark on the tapping panel *(Figure 8.12a)*. They can be controlled by insecticides such as *Lindane 20* at 2.5 ml + 1 litre water, *Tamaron 600* at 5 ml + 1 litre water, *Orthene 75S* at 1 g + 1 litre water or *Malathion LV* at 1 kg per hectare applied neat using the ULV spraying.



a) Grasshoppers & crickets

Figure 8.12 Major insects

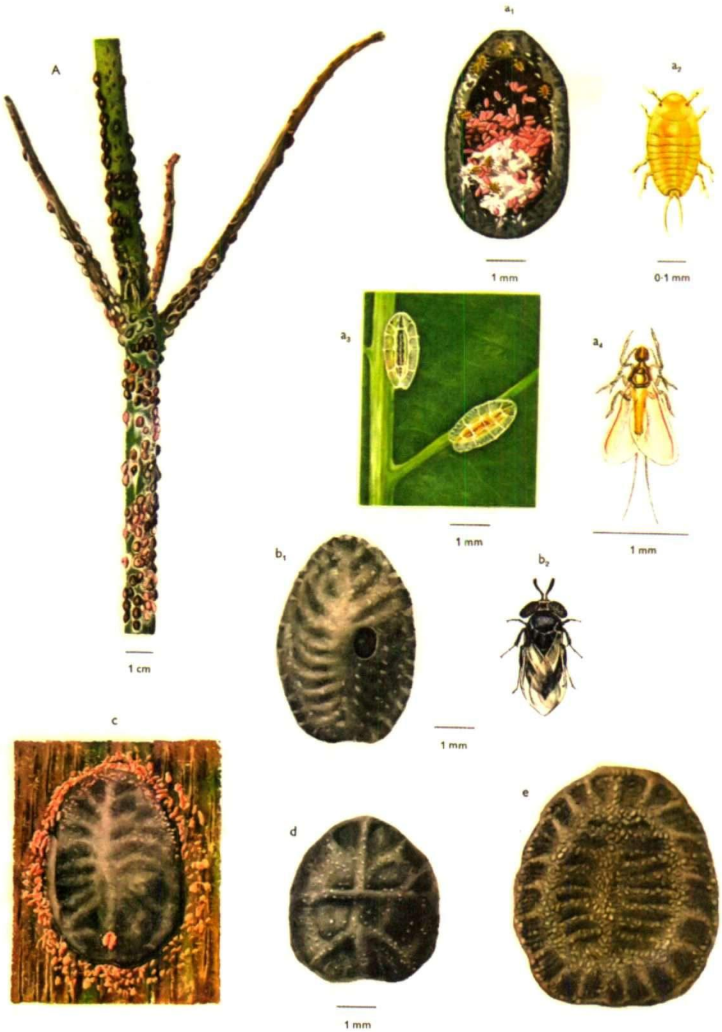
Termites. The species *Coptotermes curvignathus* can cause serious damage to rubber. This species can be identified by its soldier ant that exudes a white fluid through an opening in the head, if it is disturbed. They eat away the tap root and into the trunk of the tree. They build mudwork over the trunk, and from beneath the casing of the mudwork they feed on the bark. Young plants are killed outright, while the older ones may survive for some time until blown over by strong winds (*Figure 8.12b*). Termites can be controlled by insecticides such as *Dursban EC* at 20 ml + 5 litres water, *Lorsban 40* at a 25 ml + 5 litres water, *Stedfast* at 330 ml + 5 litres water or *Fastac* at 200 ml + 5 litres water. The insecticide is poured over the trunk of the affected tree and allowed to slip down and into the soil.



b) Termites

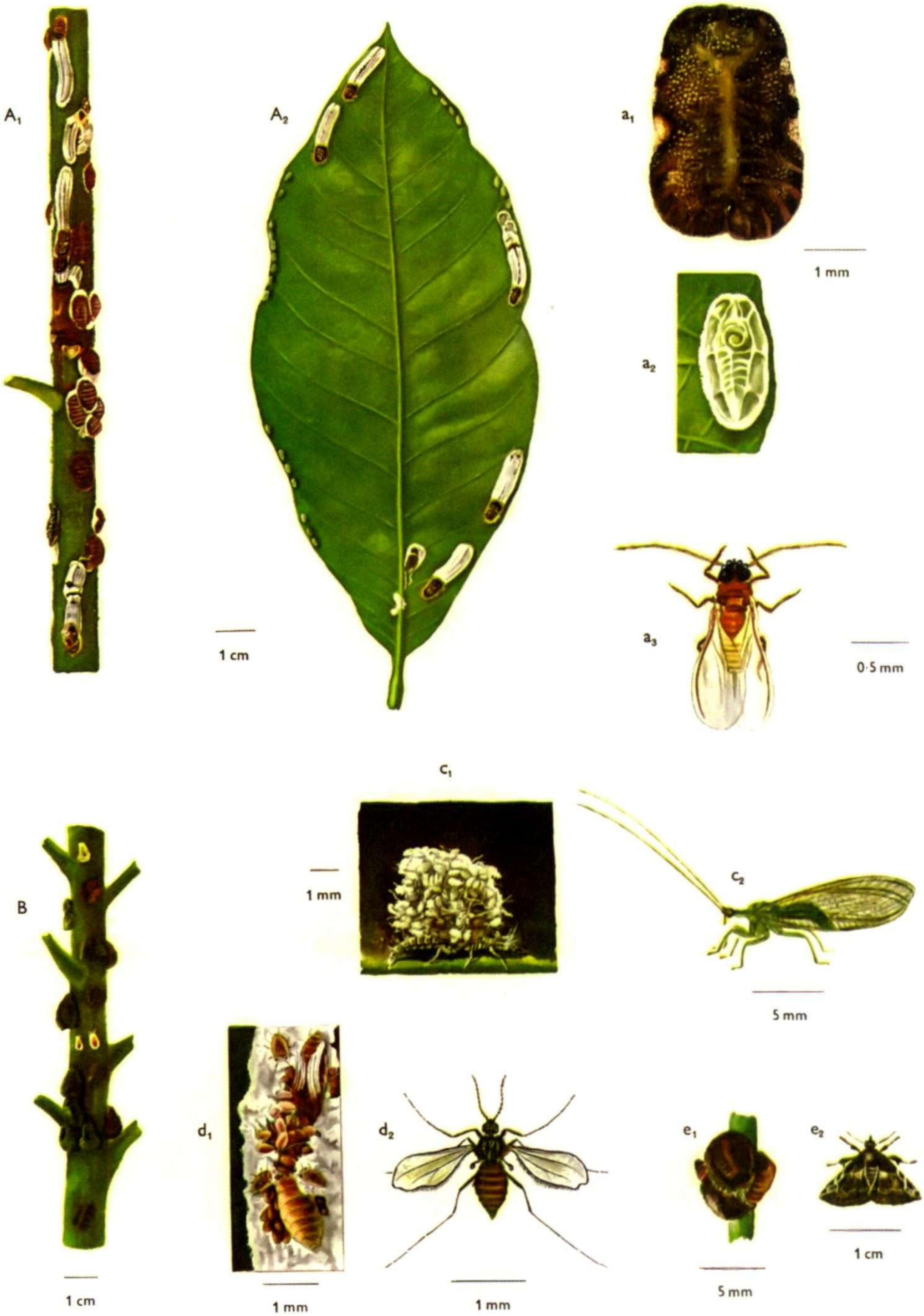
Figure 8.12 Major insects

Scale insects. The two types of scale insects that are known to attack rubber are the unarmoured scale species of *Saissetia nigra* and *Pulvinaria maxima*, and the armoured scale species of *Lepidosaphes cocculi*, *Pinnaspis aspidistrae*, *Phenacaspis dilatata*, *Aspidiouts destructor*, *Hemiberlesia palmae*, *Hemiberlesia cyanophylli*, *Parlatoria proteus* and *Pinnaspis theae*. They stick on the stems to suck the sap from the plants, weaken them and cause dieback. Very young plants can be killed (*Figure 8.12c-e*). They can be controlled by insecticides such as *Albarol White Oil* at 28 ml + 5 litres water or kerosene-soap emulsion at 28 ml + 5 litres water. Kerosene-soap emulsion can be prepared by mixing 500 g soap, 4.5 litres water and 28 ml kerosene.



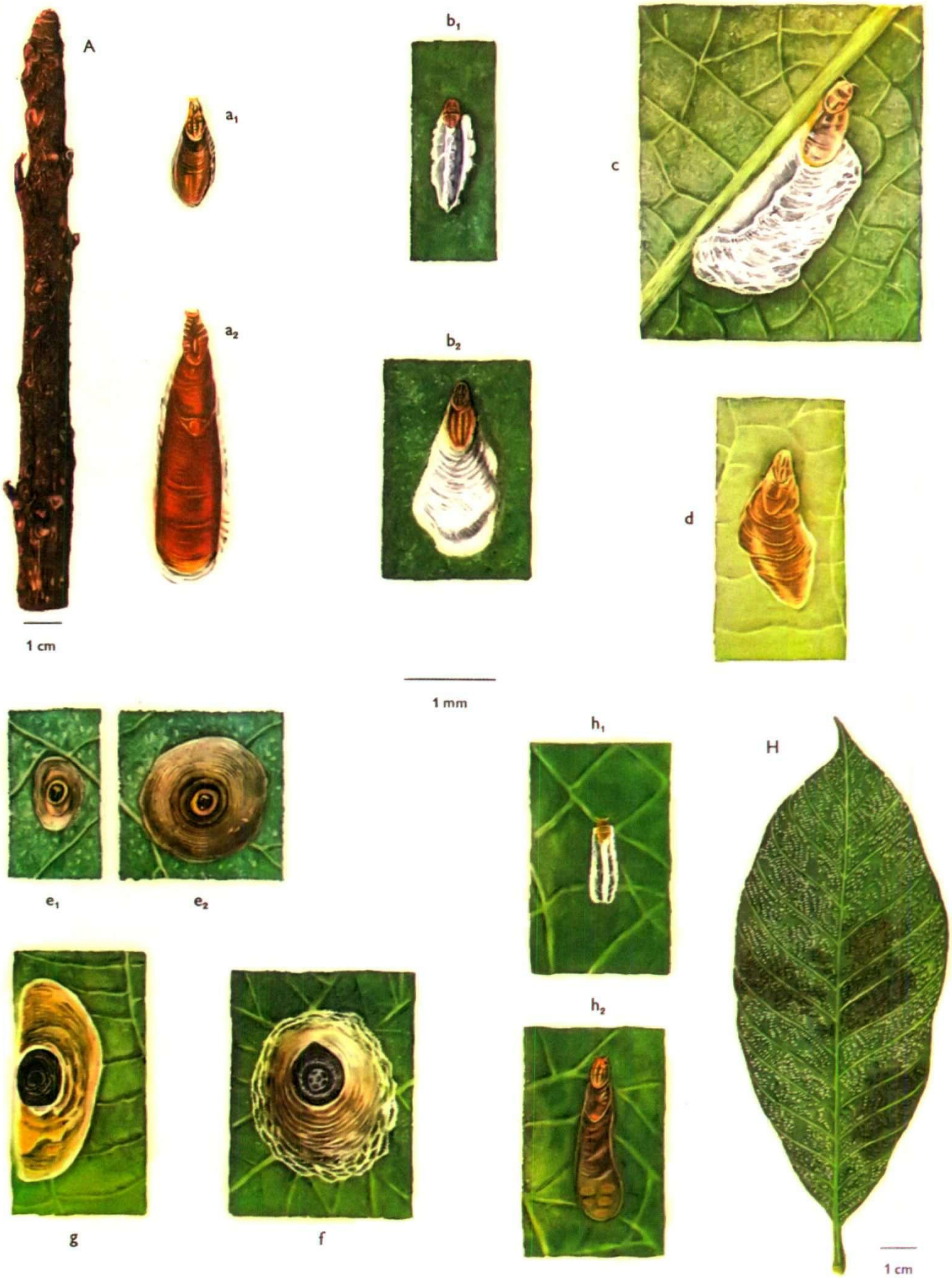
c) Scale insects

Figure 8.12 Major insects



d) Scale insects

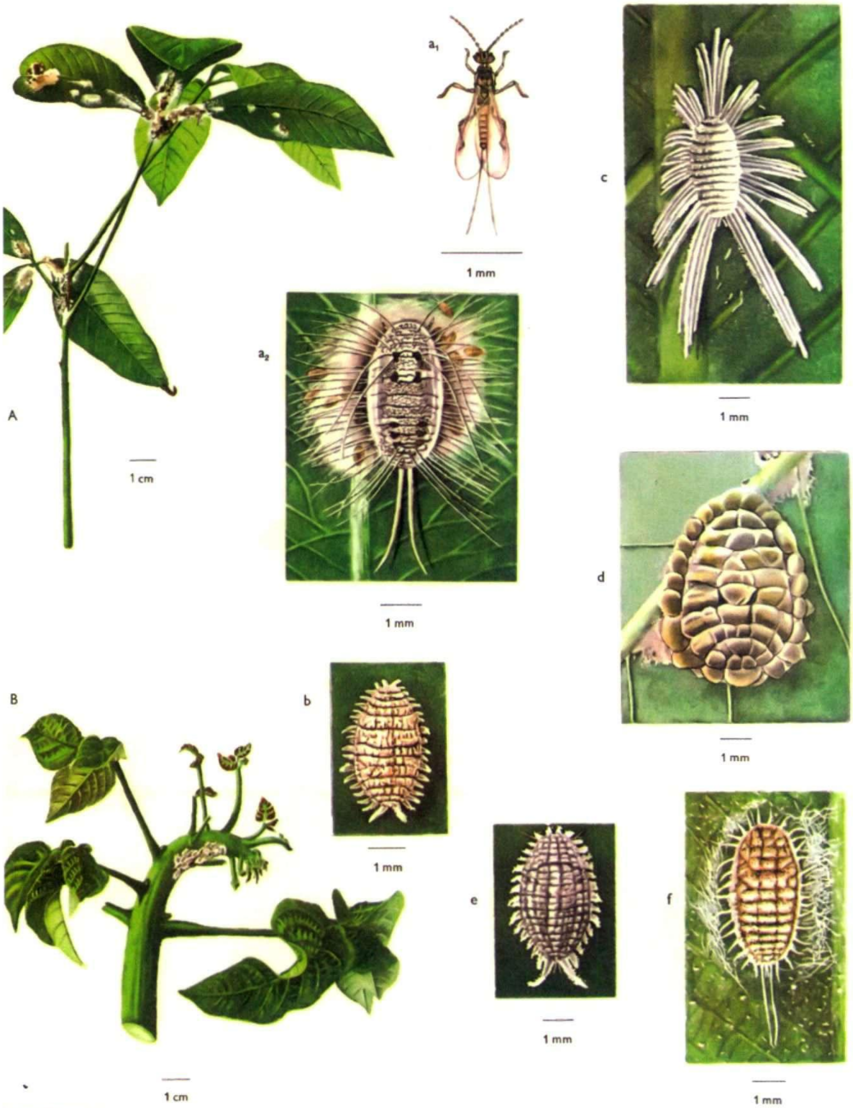
Figure 8.12 Major insects



e) Scale insects

Figure 8.12 Major insects

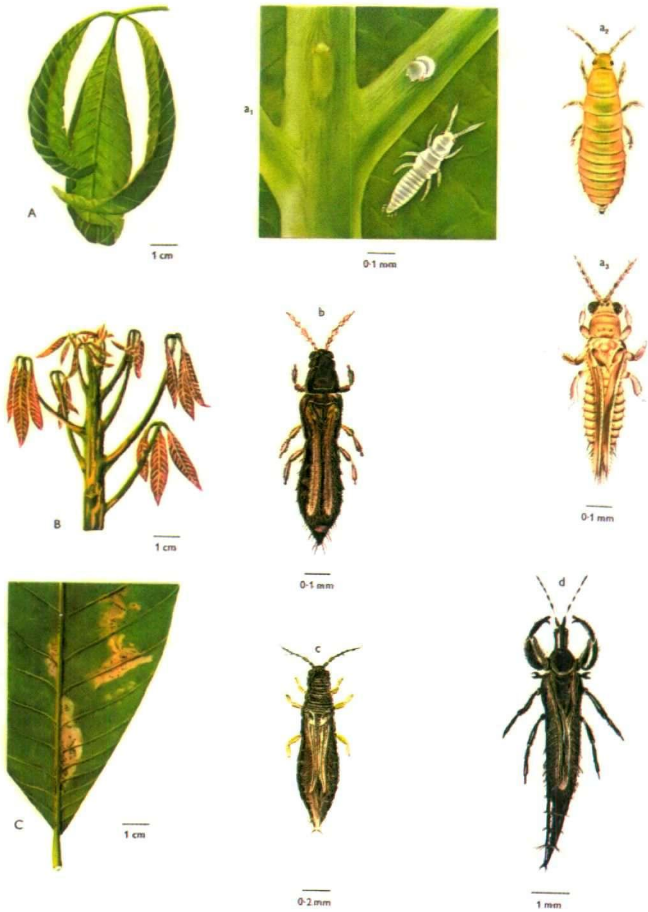
Mealy bugs. Mealy bugs are also sucking insects. The species *Ferrisiana virgata* attacks young shoots, thus causing dieback. Another species *Planococcus citri*, attacks terminal buds, causing distorted stems and crinkled leaves. Both species also attack legume covers. The species *Icerya*, *Rastrococcus iceryoides* and *Dysmicoccus sp.* attack the under surface of leaves *(Figure 8.12f)*. Control measures are the same as those for scale insects.



f) Mealy bugs

Figure 8.12 Major insects

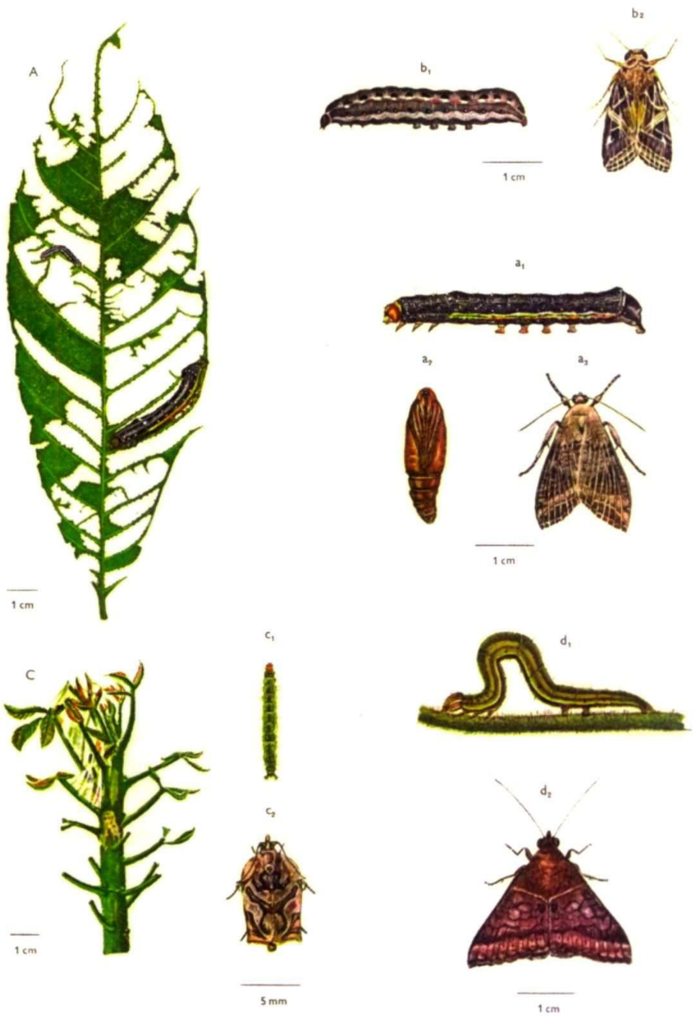
Thrips. Thrips of *Sericothrips dorsalis* species cause severe defoliation of tender leaflets of both young and old rubber. It is common during the annual refoliating season, thus contributing to secondary leaf fall. Affected leaflets curl downward like an inverted scoop and drop while the petioles are still attached to the plant. Another species, *Taeniothrips minor*, occasionally infests the region of the terminal buds concealed among the expanding leaves. Its feeding punctures cause patches of corkiness on the tender stem and on the upper surface of the petiole base. Thrips of *Heliothrips haemorrhoidalis* species eat the under surface of older leaf, while *Dinothrips sumatrensis* are commonly found below dead bark (*Figure 8.12g*). These can be controlled by insecticides such as *Mitac 20* at 10 ml + 5 litres water, but is rarely required, as the attack usually passes with change of weather.



g) Thrips

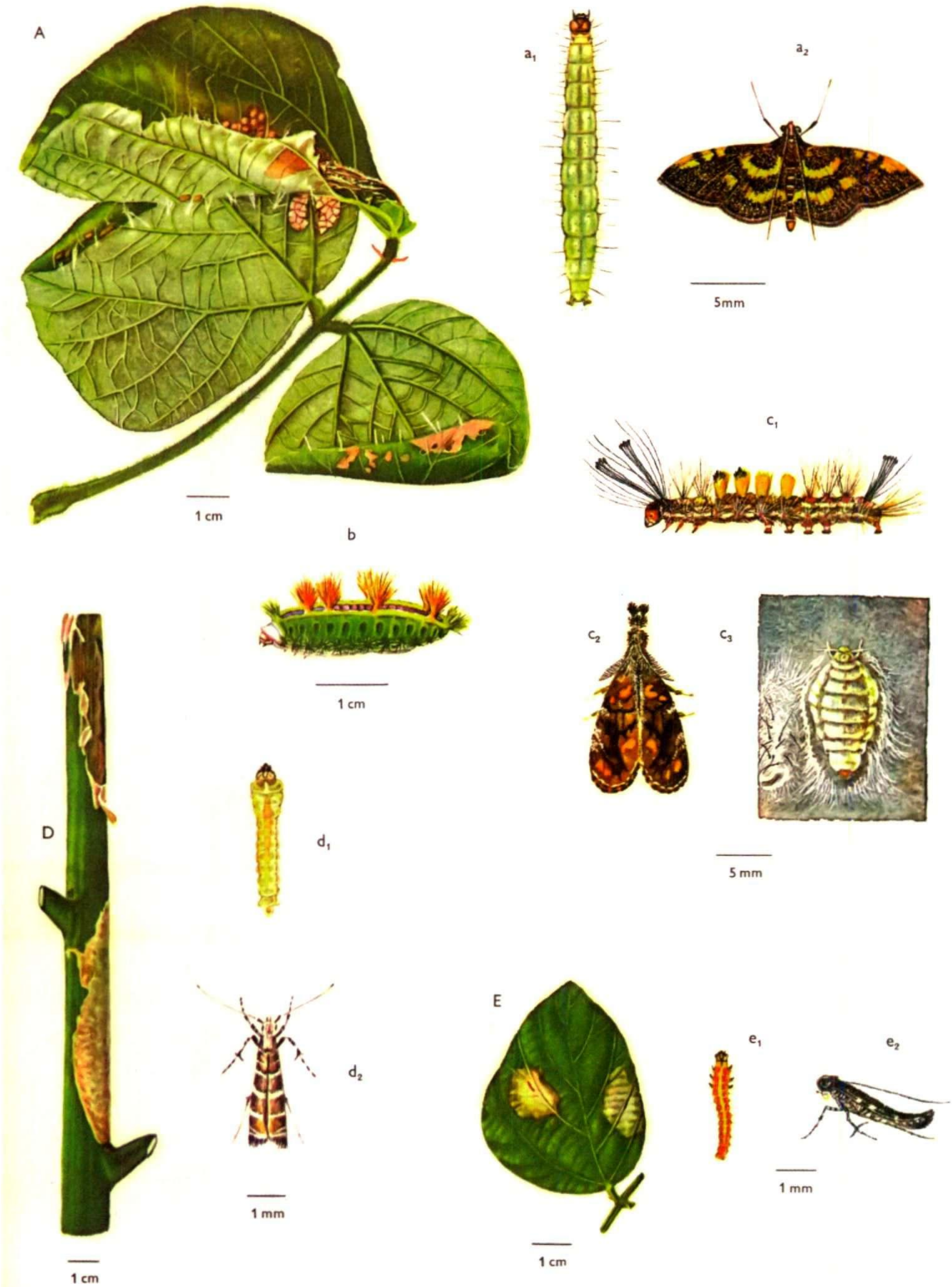
Figure 8.12 Major insects

Caterpillars. A caterpillar has thirteen body segments and a strong chewing mouth. The species *Tiracola plagiata*, *Amsacta lactinea*, *Orgyia turbata*, *Mocis undata*, *Prodenia litura*, *Clania variegate*, *Crematopsyche pendula*, *Thosea sinensis*, *Adoxophyes privatana*, *Hyposidra talaca* and *Euproctis subnotata* are known to attack rubber. Young leaves are consumed entirely, and the older ones skeletonised. *Nacoleia (Lamprosema) diemenalis* is a serious pest of legume covers. It feeds within folds or rolls of leaflets which it binds together (*Figures 8.12h and i*). They can be controlled by insecticides such as *Dipterex sp.* at 10 g + 5 litres water or *Sevin 85S* at 10 g + 1 litre water. They rarely need chemical control as they have a lot of natural enemies.



h) Caterpillars

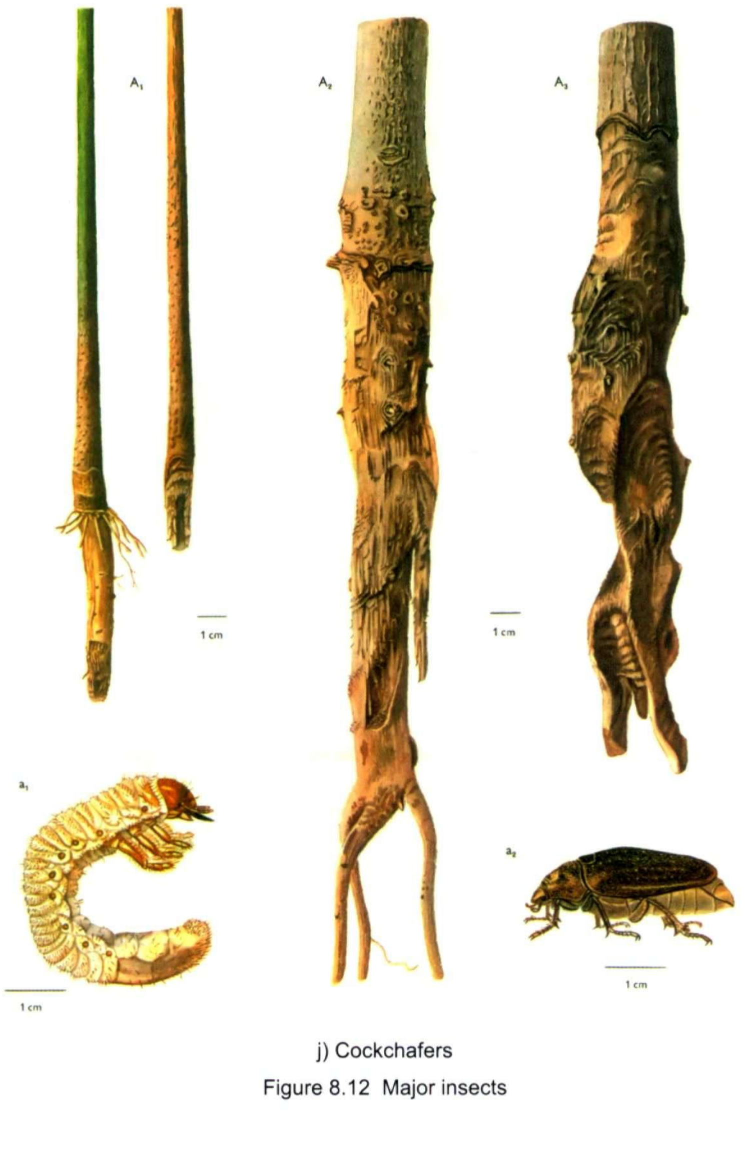
Figure 8.12 Major insects



i) Caterpillars

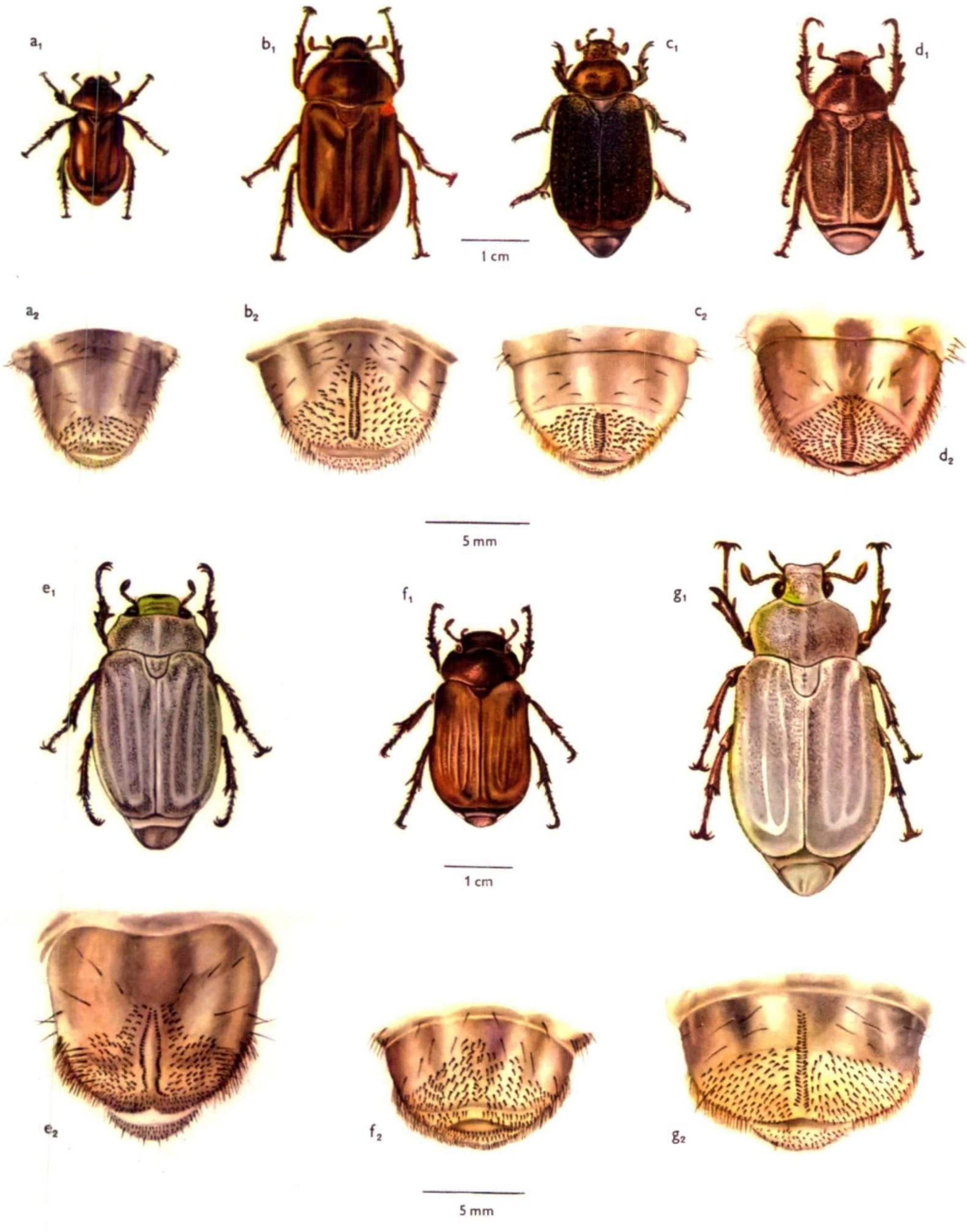
Figure 8.12 Major insects

Cockchafers. Cockchafer grubs of the species *Lachnosterna (Holotrichia) bidentata*, *Psilpholis vestita*, *Leucopholis rorida*, *Leucopholis nummicudens*, *Leucopholis tristis*, *Exopholis hypoleuca* and *Lepidiota stigma* attack rubber. They are voracious feeders, nibbling away roots of young rubber and legume covers. As root destruction progresses, the leaves turn yellow and fall, shoots dieback and the young tree dies (*Figures 8.12j-l*). They can be controlled by insecticides such as *Dursban EC* at 20 ml + 5 litres water, *Lorsban 70EC* ata 25 ml + 5 litres water or *Stedfast* at 330 ml + 5 litres water. Holes are punched in the soil around the plants and the insecticide is poured into them.



j) Cockchafers

Figure 8.12 Major insects



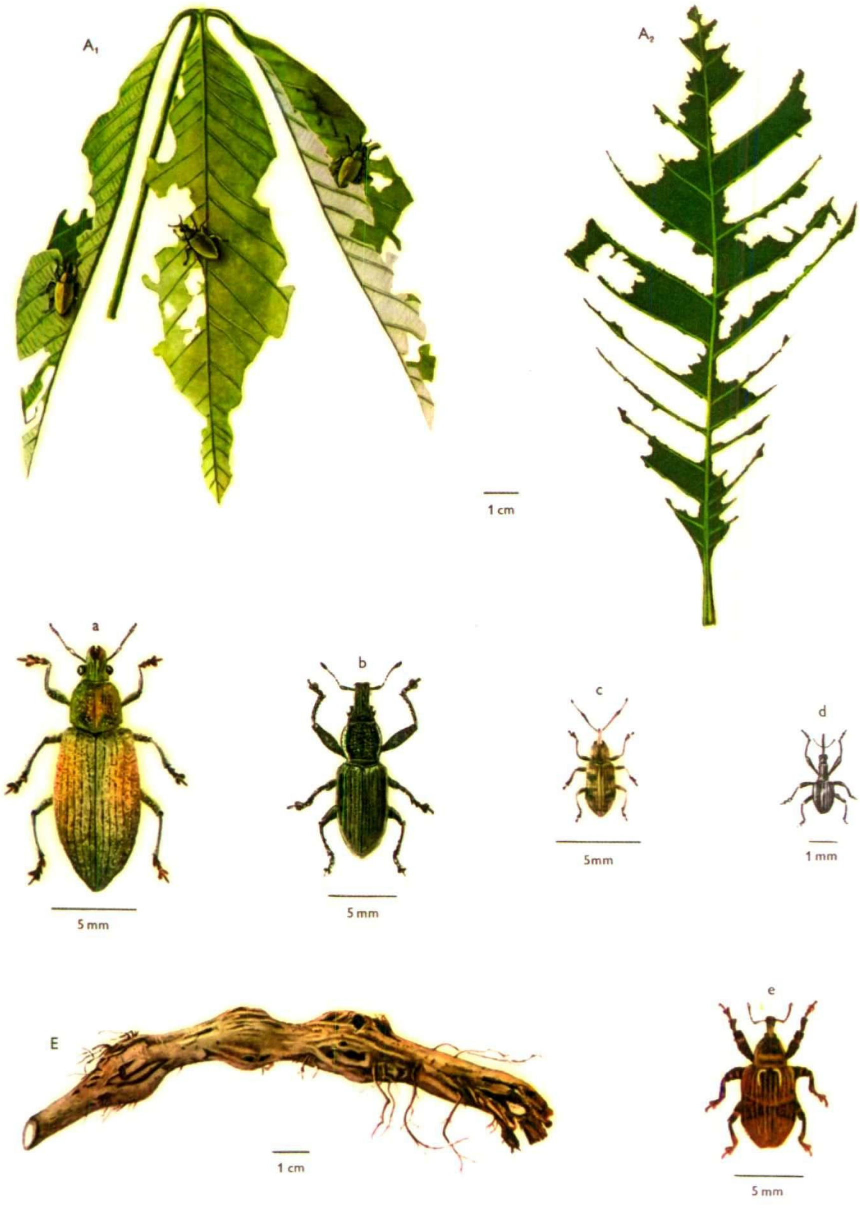
k) Cockchafers

Figure 8.12 Major insects

I) Cockchafers

Figure 8.12 Major insects

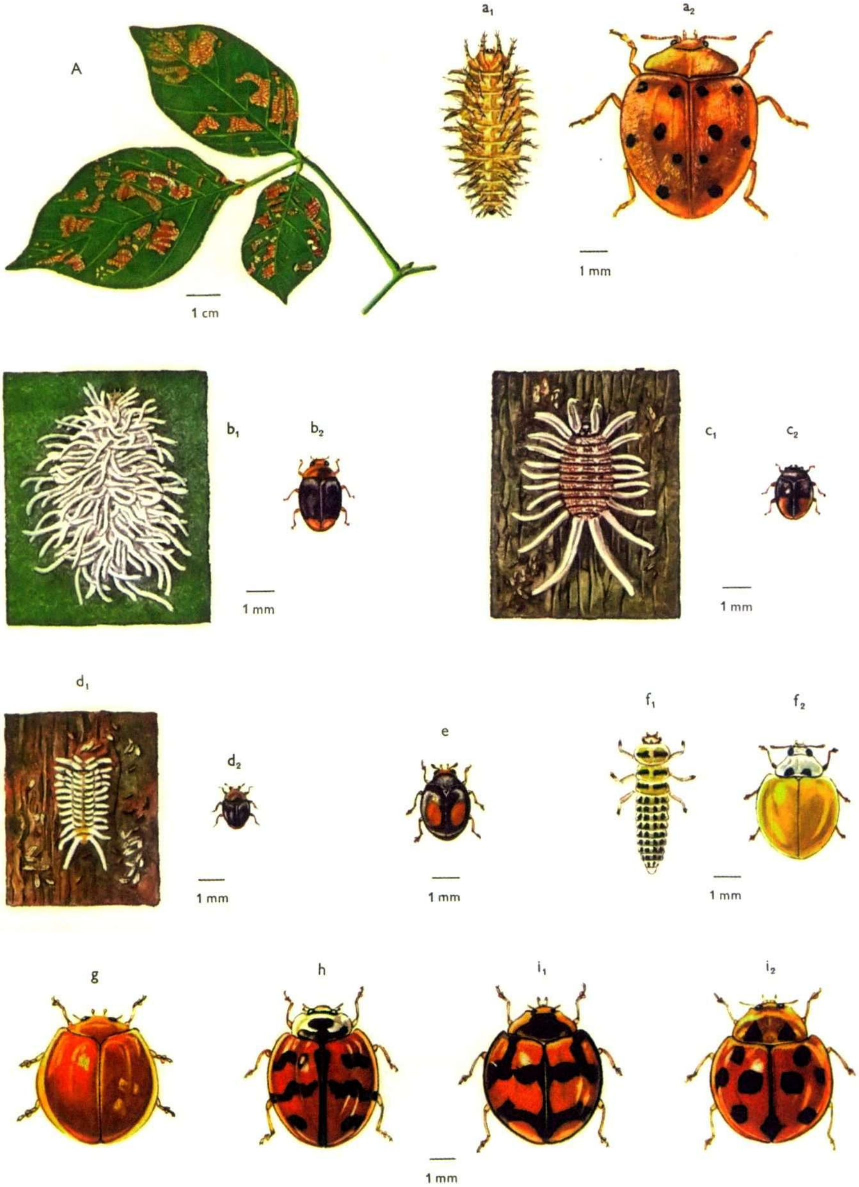
Weevils. The species *Hepomeces leporinus* attacks leaves of young rubber and legume covers. *Lepropus lateralis* eat away leaves of legume covers, while *Phytoscapus leporinus* eat rubber flowers (*Figure 8.12m*). They can be controlled by *Tamaron 600* at 25 ml + 5 litres water.



m) Weevils

Figure 8.12 Major insects

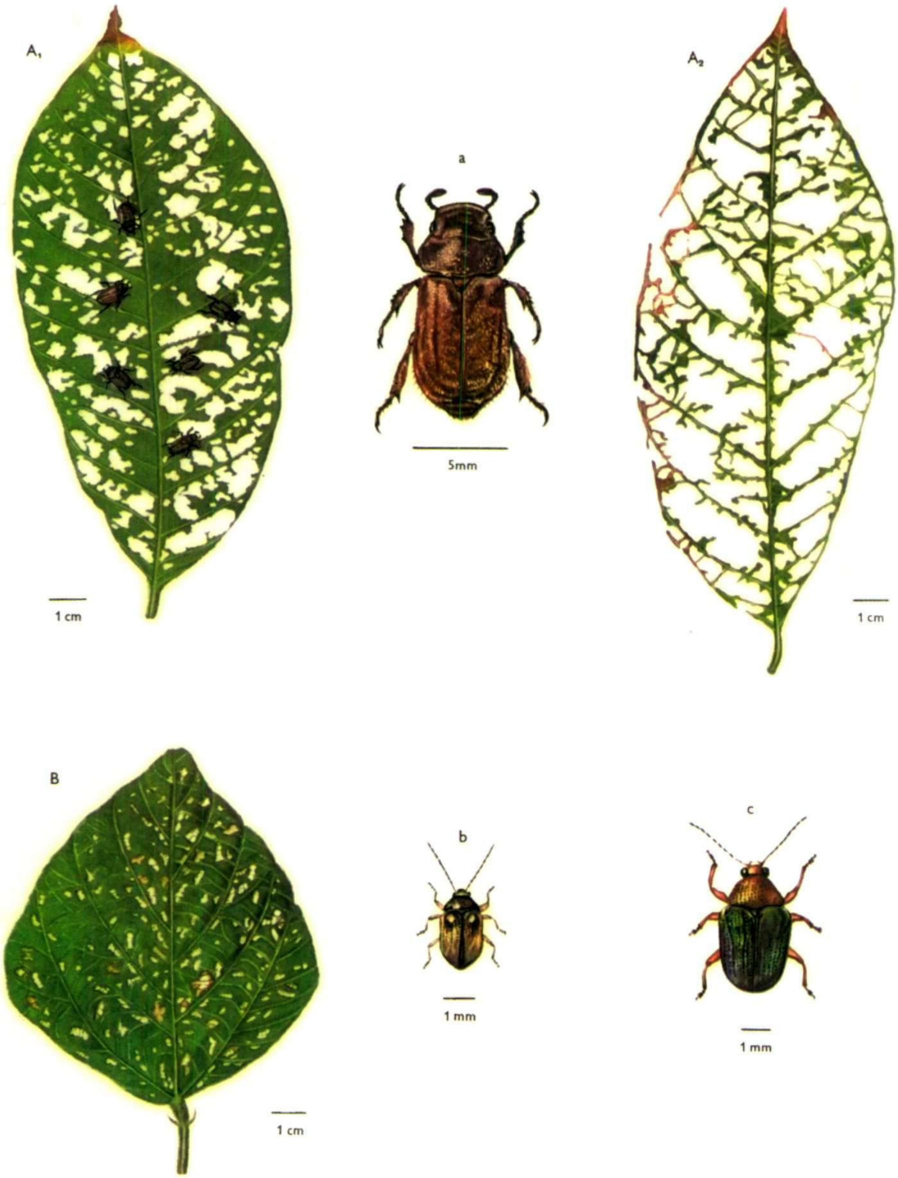
Ladybird beetles. The species *Epilachna indica* destroys legume covers, especially *Entrosema pubescens*, eating away the tissues between the veins, thus skeletonising them (*Figure 8.12n*). They can be controlled by spraying with *Sevin 85S* at 20 g + 5 litres water.



n) Ladybird beetles

Figure 8.12 Major insects

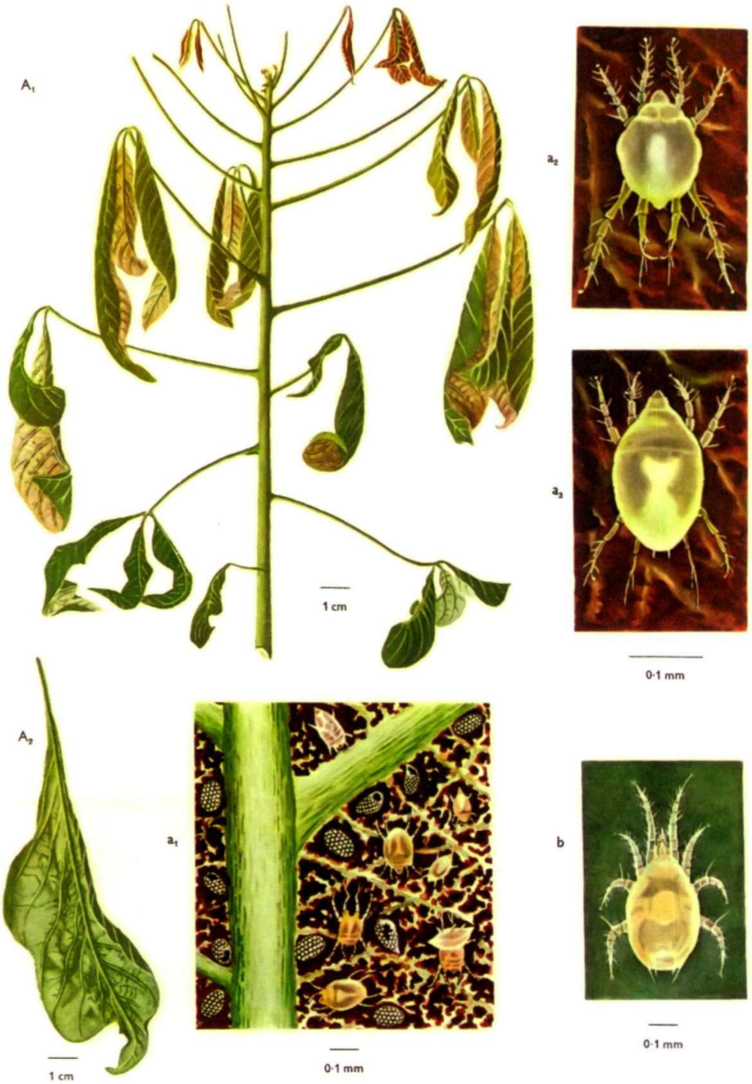
Leaf-eating beetles. Beetles of the *Adoretus compressus* species eat away older leaves until skeletonised, and the species *Pagria signata* eats away leaves of *Pueraria phaseoloides* and *Calopogonium mucunoides*, while the *Nodostoma aeneipenne* species attacks *Moghania macrophylla* (*Figure 8.12o*). They can be controlled by spraying with insecticide, such as *Sevin 85S* at 25 g + 5 litres water.



o) Leaf-eating beetles

Figure 8.12 Major insects

Mites. The yellow tea-mite of the species *hemitarsonemus latus* is a common insect pest of rubber nurseries. It attacks young rubber leaves, causing severe distortion and defoliation whenever new flushes appear. In mature rubber, the newly refoliating leaves that appear after wintering are attacked, causing another leaf fall. This pest is therefore an agent of secondary leaf fall (*Figure 8.12p*). They have several natural enemies that can help in controlling them. For chemical control, insecticide such as *Mitac 20* at 25 g + 5 litres water can be used.



p) Mites

Figure 8.12 Major insects

Molluscs

Molluscs are soft-bodied animals with sole-like feet on which they glide with distinctive heads bearing two pairs of tentacles, the longer rear pairs bearing the eyes at the ends. They are present in great numbers during the wet season. They attack by night and hide during the day, where low vegetation and leaf litter such as the legume covers, provide them with good shelter. Their brief descriptions are given below.

Snails. Snails have protective shells over them. The species *Achatina fulica, Eulica similaris, Subulina octona and Xestina striata* are pests of legume covers and rubber, as they eat away the leaves. Snails also climb up tapped trees to suck the latex along the tapping cuts, and also cause spillage (*Figure 8.13a*). They can be controlled by poisoned baits consisting of powdered metaldehyde, hydrated lime and rice bran, in the ratio of 1:4:6 by weight. The ingredients are mixed together with about the same volume of fresh rubber latex diluted in equal volume of water. The mixture is then kneaded throughly into crumbs which are air-dried under shade. The poisoned baits are spread all over the plantation, especially at the borders of places where they are expected to take shelter.

Slugs. Slugs do not have protective shells over them. The species *Mariaella dussumieri* and *Parmarion martensi* are capable of damaging young plants. They climb up the stems to eat the terminal buds, and when the side shoots appear, these too are eaten away. Repeated attacks result in stunted clustered shoots (*Figure 8.13a*). Another slug, *Vaginula bleekerie*, is more of a legume cover pest, causing extensive damage to the foliage and shoots. Slugs also suck latex from tapping cuts of tapped trees. Control measures are the same as those described above.

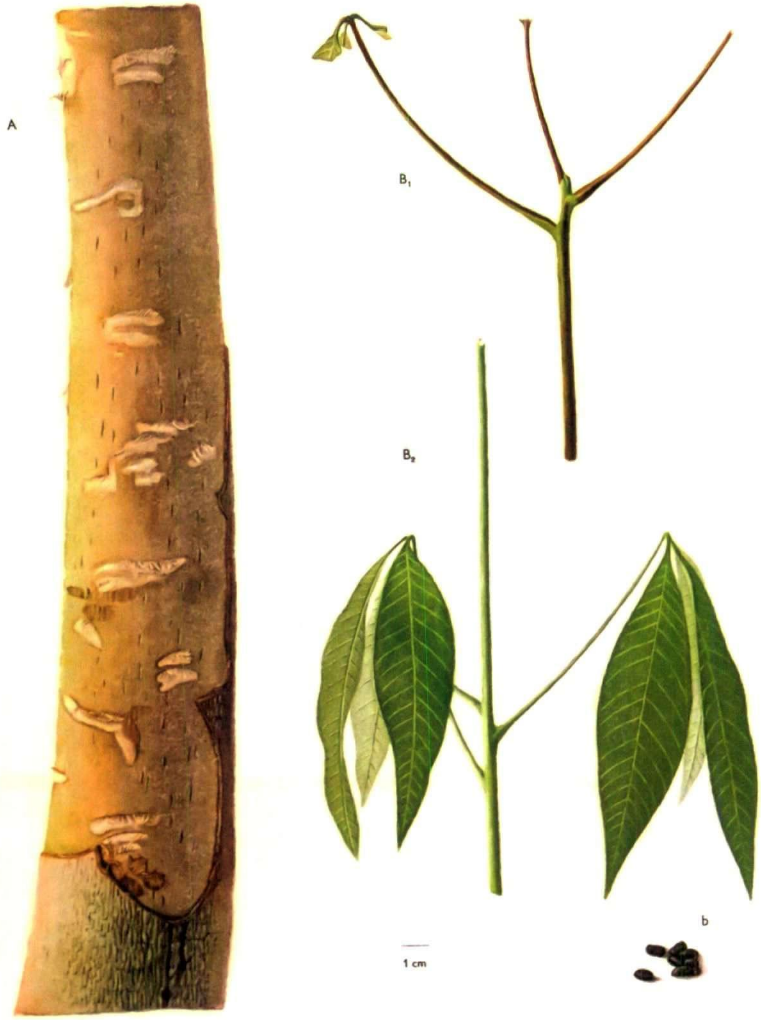
Mammals

Mammals are group of animals which are warm-blooded. There are nine of them which are pests in rubber cultivation. Brief descriptions of them are given below.

(a) Damage caused by snails and slugs

Figure 8.13 (a – i) Molluscs, mammalian and pest damage

Deer and mousedeer. There are two deer species namely, *Cerva unicolor* (the sambur deer) and *Muntiacus muntjac* (the barking deer), while there are also two species of mousedeer, *Tragulus javanicus* (kancil) and *Tragulus napu* (napuh). They live in the jungle but roam the bordering plantation for food. The sambur deer feed on the bark, stripping it off from the trunk. Barking deer and mousedeer nibble away the foliage that they can reach (*Figure 8.13b*). They can be kept away by applying repellent substance such as *Hinder* on the trunk, especially on rubber trees bordering the jungle.



(b) Damage caused by deers and mousedeers

Figure 8.13 (a – i) Molluscs, mammalian and pest damage

Wild boars. Two species are found in Malaysia, namely the common *Sus scrofa* and the bearded *Sus barbatus*. They eat the cotyledons of germinating seeds, uproot young plants and eat away the roots while the bark of older trees are often stripped off (*Figure 8.13c*). Wild pigs can be kept away by perimeter fencing with several strands of closely spaced barbed wires and wire netting. They can also be trapped or killed by poisoned baits such as zinc phosphide-inserted sweet potato.

(c) Damage caused by wild boars

Figure 8.13 (a – i) Molluscs, mammalian and pest damage

Rats. Rats come under the group of pests known as rodents. There are two rats species attacking rubber, *Rattus jalorensis* and *Rattus argentiventer*. Damage caused by rats can be serious in areas where the undergrowth are not controlled. Rats eat cotyledons of germinating seeds, and nibble away the bark of young plants. They sometimes eat the terminal buds, too (*Figure 8.13d*). They can be controlled by rodenticide such as zinc phosphide mixed with suitable bait in the ratio of 1:19 by weight. They can also be trapped by applying tanglefoot preparation which is available under the trade name of *Atom*.

(d) Damage caused by rats

Figure 8.13 (a – i) Molluscs, mammalian and pest damage

Bamboo rats. Bamboo rats are also rodents. Two species, *Rhizomys sumatrensis* and *Rhizomys pruinosus*, are pests of rubber. Bamboo rats live in burrows near thick bamboo clumps. Seedling trees of one to three years old are bitten around the collar region until they fall. Stems of smaller seedlings are sometimes cut into short lengths and carried into their burrows (*Figure 8.13e*). They can be caught in cage traps using young bamboo shoot or sweet potato as bait. Bamboo rats are protected animals. Once caught, they must be handed over to the Department of Wildlife and National Parks.

(e) Damage caused by bamboo rats

Figure 8.13 (a – i) Molluscs, mammalian and pest damage

Porcupines. Porcupines also come under the rodent group. The species known as *Hystrix brachyura* is a pest of rubber. It has a short tail with long sharp pointed quills on the body. It lives in the forest but enters the plantation in search of food. It feeds on the bark of the rubber tree. Plants are sometimes pulled out of the soil and the tap roots eaten away (*Figure 8.13f*). It can be kept away by perimeter fencing or caught in cage trap using salted meat as bait. It is also a protected animal, and must be handed over to the Department of Wildlife and National Parks (DWNP).

(f) Damage caused by porcupines

Figure 8.13 (a – i) Molluscs, mammalian and pest damage

Squirrels. Two species, *Callosciurus notatus* and *Callosciurus caniceps* are pests of rubber. They are frequently found in plantations where the inter-row undergrowths are not controlled. They eat away stems of young rubber seedlings which are cut into half way at the base and split upward to expose the pith, which are also eaten away. They also consume latex from two to four year old trees and cause bark injuries. The teeth mark injuries are spirally made on the stems. They also eat the seeds and renewed bark (*Figure 8.13g*). They can be shot or trapped.

(g) Damage caused by squirrels

Figure 8.13 (a – i) Molluscs, mammalian and pest damage

Tree shrews. Two species, *Tupaia glis* and *Tupaia minor*, attack rubber. They closely resemble squirrels. Tender scion shoots are cut and partly eaten away. Similar damage to seedlings are also believed to be done by them (*Figure 8.13h*). They can be caught in cage traps or by applying tanglefoot preparation which is available under the trade name *Atom*.

(h) Damage caused by tree shrews

Figure 8.13 (a – i) Molluscs, mammalian and pest damage

Monkeys. Five monkey species are known to attack rubber. They are *Presbytis melalopos, Presbytis obscurus, Presbytis cristatus, Macaca nemestrina* and *Macaca irius*. Young plantings bordering the forests are frequently attacked. They feed on shoots, foliage and young fruits. Branches are broken when they swing on them. Seedlings are also pulled out and the tops eaten away. They also bite away the bark (*Figure 8.13i*). They are controlled by shooting.

(i) Damage caused by monkeys

Figure 8.13 (a – i) Molluscs, mammalian and pest damage

Elephants. Elephants cause damage to rubber by eating away the shoots. But much damage is caused by their tramplings on crops. They can be kept away by electric fencing such as the *FELDA Felefence* or reported to the Department of Wildlife and National Parks for action.

CHAPTER 9

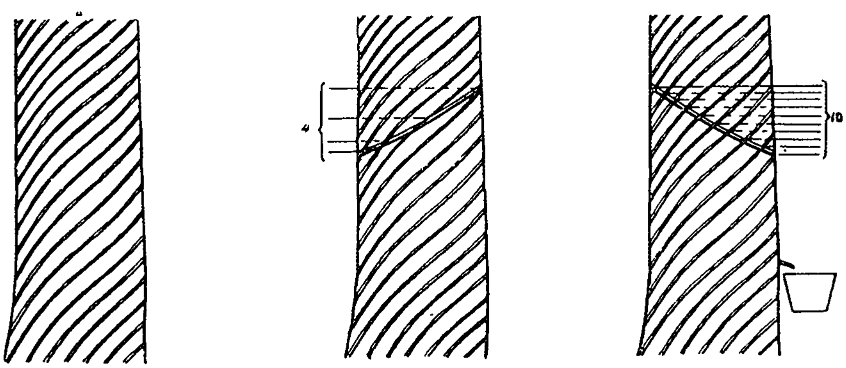
LATEX HARVESTING

TAPPING

Latex from the rubber tree had been used by the people of Brazil long before Columbus crossed the Atlantic. Demand for raw natural rubber started to increase after the discovery of the vulcanisation process in 1839. However, production of rubber did not increase significantly as there was no large-scale planting of the crop and the method of extracting latex from the rubber tree was not systemised. During the period, latex was extracted by making indiscriminate incisions on the tree. Such a method resulted in excessive wounds on the tree trunk and rendered the trees useless in a very short period of time. Conditions became better, when in 1889, H N Ridley discovered the excision method of tapping which is still in use until today. This discovery attracted large-scale planting of rubber.

Direction and Slope of Tapping Cut

Latex flows through latex vessels found in the bark of the rubber tree. Latex vessels run spirally from low left to high right at an inclination of 3.7-5° from the vertical. Latex will flow out of the bark, only if the latex vessels are severed or cut. The more latex vessels are severed, the more will be the flow of latex. Therefore, the tapping cut is made in the opposite direction of the latex vessels, that is, from high left to low right *(Figure 9.1)*.



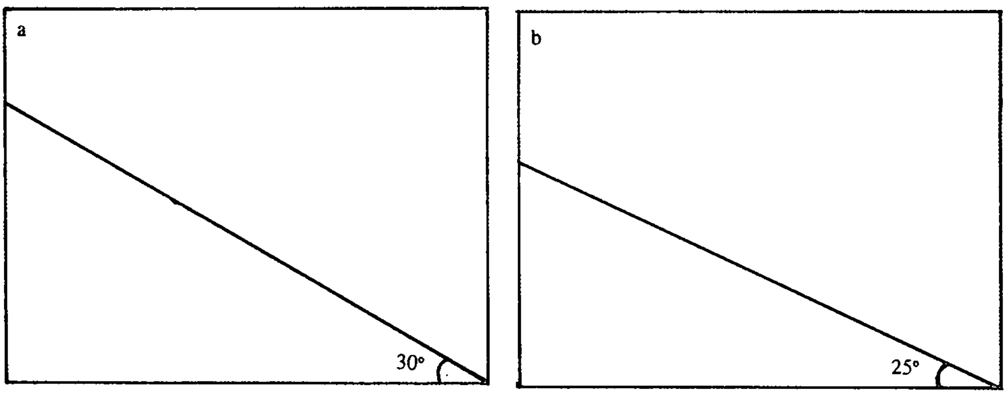
(a) Position of latex vessels in the bark

(b) Wrong direction of tapping cut

(c) Recommended direction of tapping cut

Figure 9.1: Direction of tapping cut

The slope of the tapping cut is made at such an angle that gives maximum yield with minimum bark consumption and a fast flow of the latex along the tapping cut into the latex cup. The tapping cut angle of the slope influences the length and bark consumption, which in turn is related to yield. Basically, an increase in the angle of slope of tapping cut gives higher yield. Based on experiments, for clonal materials, the slope of the cut is recommended at an angle of 30°, while for the clonal seedlings at 25° from the horizontal *(Figure 9.2).* This means that the slope of cut for clonal material is 5° more than that for the clonal seedling. The bark of the clonal material is generally thinner due to less corky layer but contains more latex vessels. Its increased slope is to enable the latex to flow faster along the tapping cut, thus avoiding an overflow over the trunk. On the other hand, the bark of the seedling tree is thicker. The 25° slope is therefore adequate to cause an efficient flow of its latex along the tapping cut.

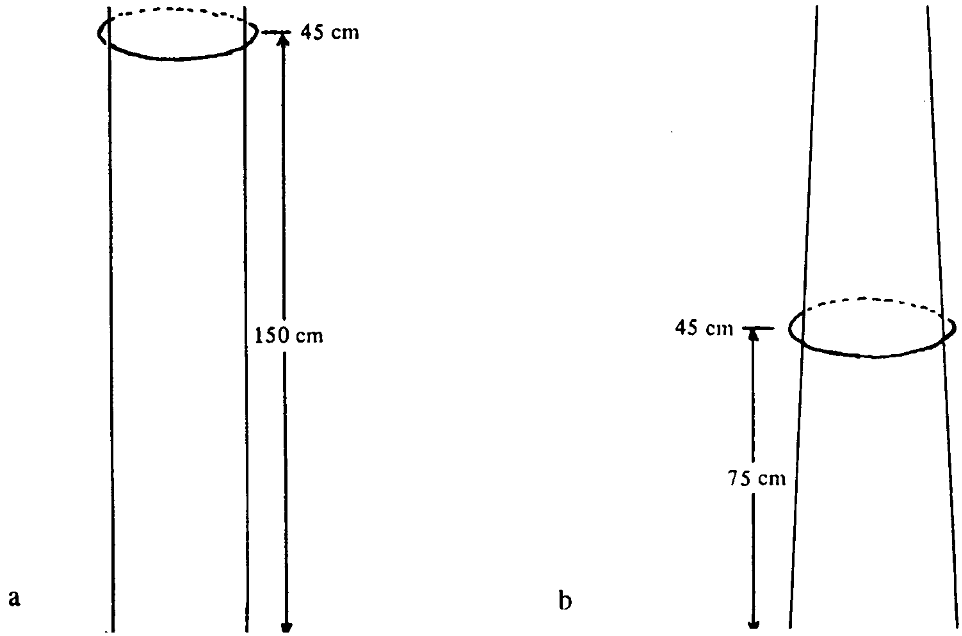


(a) For buddings (b) For clonal seedlings

Figure 9.2: Angle of tapping cut

Height of Tapping Cut

For the clonal materials, the recommended height for opening of tapping panel is 150 cm, while the seedling materials it is 75 cm from the ground level *(Figure 9.3).* Clonal materials are opened much higher than seedlings because of their cylindrical shaped trunks. Furthermore, there is no significant variation in yield when opened tapped at any height on the trunk. Therefore, the tapping cuts are open as high as possible on the trunk. On the other hand, the trunks of seedlings taper upward, as a result, more latex vessels can be found lower down the trunk. The tapping cuts on seedlings are therefore opened as low down the trunk as possible. For both types of planting materials, the trunk girths must attain 45 cm at opening of tapping panels at their respective heights. *(Figure 9.3).*



(a) For buddings

(b) For clonal seedlings

Figure 9.3 Height of opening of tapping panel and girth size

Task Size

Task size is the number of trees in a task given to a tapper to complete tapping at a specified time. The number is based on several factors such as girth size, density per hectare, tapping system and the topography of the area. Basically, when tapping alternate daily, at half spiral, a tapper is given 500-600 trees per day of tapping task.

Time of Tapping

Tapping is carried out as early as possible in the morning and that is why it is always referred to as dawn tapping. Though no time is specified, it starts as soon as the tapping panel is clearly visible without the use of aided light. As the full impact of sunlight is not yet present, transpiration rate is still very low. Thus the cells of the rubber trees are still in turgid condition and, therefore, effect an efficient flow of the latex in the vessels. The turgor pressure within the tree is also high during this period, thus resulting in a faster flow of the latex. When tapping is done along the tapping cut, the ends of the latex vessels are again severed and latex oozes out along the cut and drips into the cup. After some time, the drip stops due to the plugging of the latex vessel ends by coagulated latex *(Table 9.1)*.

TABLE 9.1 QUANTITY OF LATEX FLOW BY TIME OF TAPPING

Time of tapping	Quantity of latex per tree (ml)
0400	155
0830	129
1230	112

Depth of Tapping

The bark of the rubber tree is made up of several layers. The outermost is called the corky bark, which acts as a protective layer. In the second layer, which is the hard bark stone cells and several unorganised latex vessel rings can be found. The greater number of latex vessel rings are found in the soft bark, which forms the third layer. The latex vessels in the bark are in rings which are closer to one another as they reach the wood. Between the bark and the wood is the cambium layer, with the medullary rays running horizontally across the bark *(Figure 9.4)*.

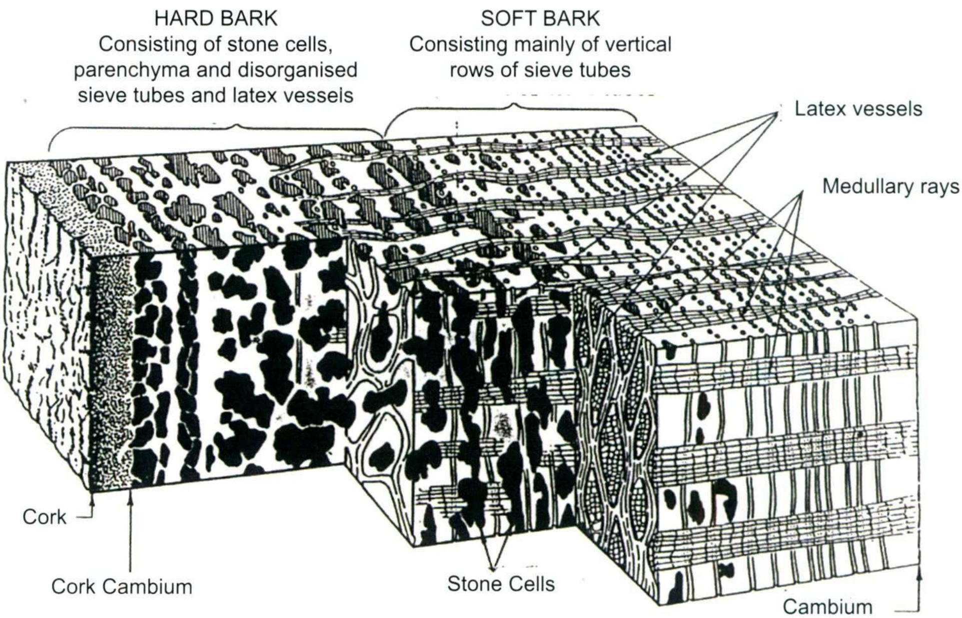


Figure 9.4 Three dimensional cross-section of the bark of the rubber tree

Tapping requires skill, which can be acquired by constant practice. The efficiency of the tapper can influence the yield obtained. As the number of latex vessel rings are greater towards the inside, tapping must be deep enough to sever as many latex vessels as possible *(Table 9.2)*. However, to avoid contacting the cambium, 1 mm of bark should be left untapped. This will enable faster renewal of bark *(Figure 9.5)*. Tapping to adequate depth can give three times the amount of yield compared to shallow tapping. On the other hand, too deep tapping results in lower dry rubber content (DRC) of latex, because the resultant latex gets mixed up with water from the cambium layer. Too deep tapping also damages the cambium and this result in wounds, and uneven renewed bark, rendering tapping difficult later on. If tapping has been done well, the regenerated bark is smooth and should be thick enough for retapping in six years' time.

TABLE 9.2 RINGS OF LATEX VESSELS SEVERED BY DEPTH OF TAPPING

Depth of tapping (mm from cambium)	Number of latex vessel rings severed
2.0	38
1.5	48
1.0	62
0.5	80

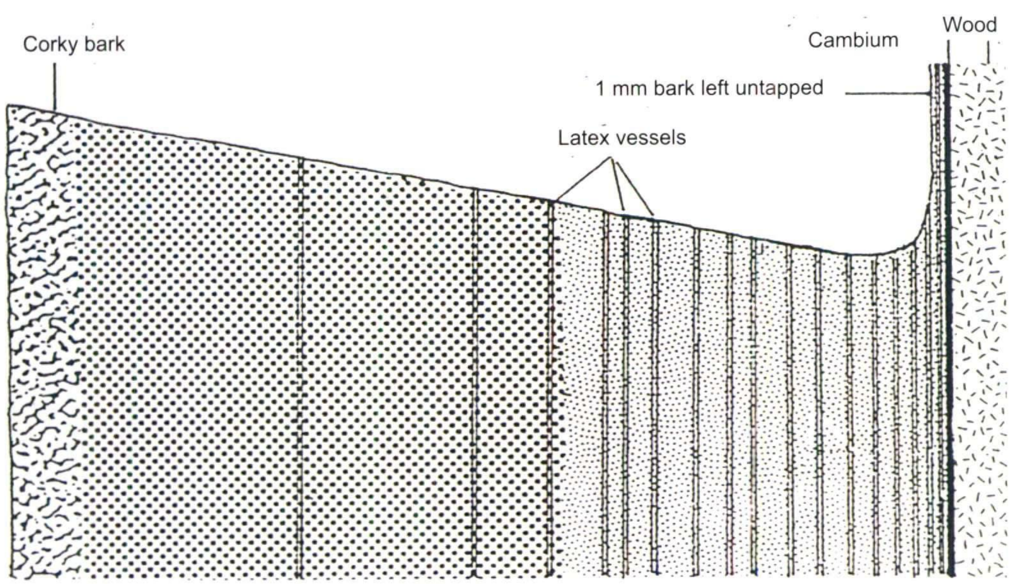


Figure 9.5 Cross-section of the bark showing depth of tapping

Thickness of Tapping

Latex can only be found in the latex vessels, which have to be severed for the latex to flow out. This can be done by slicing away the bark. The same amount of latex is obtained irrespective of the thickness of the bark removed. But a thick slice definitely removes a lot of bark and this reduces the economic life of the tree. Therefore, good tapping is to just remove the plugs at the ends of the latex vessels severed during the previous tapping *(Figure 9.6)*. It is estimated that, for alternate daily tapping, only 1 mm thickness of the bark is required to be removed in order to achieve a satisfactory flow out of latex. As a guide, the yearly bark consumption is given in *Table 9.3*. Spot marks can be made on the tapping panel on the first day of each month to show the thickness of bark consumed in a month. To prevent excessive consumption of bark, spot marks on the bark to be consumed monthly are placed on the untapped panel instead. This can be easily implemented by using a rollmarker *(Figure 9.7)*.

TABLE 9.3 YEARLY BARK CONSUMPTION GUIDE

Frequency of tapping	Type of bark	Thickness of bark consumed (cm)
Alternate daily	Virgin	20-25
	Renewed	25-30
Third daily	Virgin	18-20
	Renewed	20-25

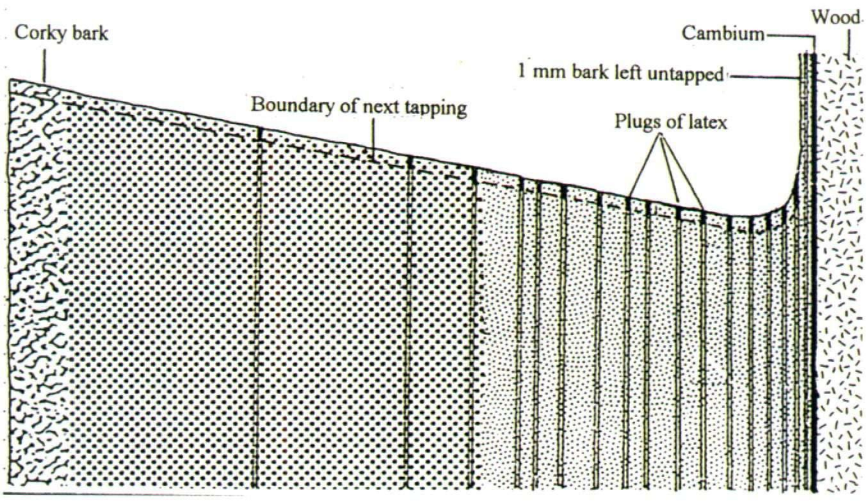


Figure 9.6 Cross-section of the bark showing thickness of tapping

(a) Thickness of bark consumed

(b) Thickness of bark to be consumed

Figure 9.7 Monthly bark consumption guide markings

Tapping Knife

The tapping knife is considered a very important item, as it assists in determining the depth and thickness of tapping. It must be sharp enough so as to enable it to slice away efficiently optimum amount of bark. On the other hand, a blunt knife needs greater force to pierce it into the bark, rendering it difficult to control and finally causing damage to the cambium. Basically there are two types of tapping knife – the one that cuts by pushing known as gouge, while the one that cuts by pulling, known as jebong. The jebong knife, if sharpened at both ends has dual functions of pushing and pulling, and is also known as bidirectional tapping knife. A modified gouge is needed for upward tapping and the controlled upward tapping (CUT) is suitable for this purpose. A prototype motorised tapping knife using battery power named Motoray was invented during the 1980's. However, it is not in use currently. *Figure 9.8* shows the development of the tapping knife from the early U-shaped gouge to the modern battery-powered Motoray.

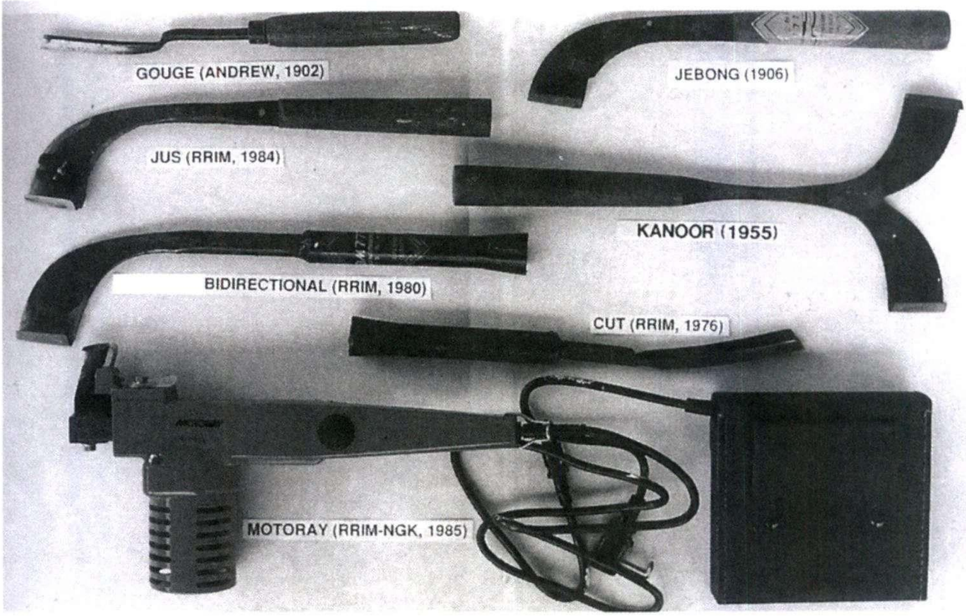


Figure 9.8 Development of tapping knives in Malaysia

Disturbance of Rain Towards Tapping and Yield

In Malaysia, rainfall considerably upsets tapping and production. Rain water that flows down the trunk from the crown causes the panel to be wet and upsets the flow of latex along the tapping cut when tapping is done the following morning. Fixing a rain guard over the panel can overcome such problem *(Table 9.4).* This was introduced in 1989 and given the trade name of *RRIMGUD*. Subsequently, another improved rain guard made from bitumen based material was introduced. This is called the raingutter and is currently available in the market. *(Figure 9.9).*

TABLE 9.4 ADDITIONAL TAPPING DAYS AND YIELDS OBTAINED WITH THE USE OF *RRIMGUD*

Item	Site A (2 months)			Site B (2 months)		
	Control		*RRIMGUD*	Control		*RRIMGUD*
Total no. rainy days		19			99	
Tapping days:						
Dry and tappable	31		29	185		185
Saved from rain interference	-		12	-		9
Total	31		41	185		194
Yield (kg):						
Dry and tappable	284		233	4,108		4,300
Saved from rain interference	-		85	-		247
Total	284		318	4,107		4,547

Site A : Clone PR 255, PR 261 and GT 1
Site B : Clone PB 260

Figure 9.9 Rainguard

TAPPING CENSUS

Rubber tree girths are measured from time to time to determine the time of opening for tapping. This operation is in fact a continuation of the growth census which starts when the trees are one year old. Tapping census or survey commences when the girths have reached 35 cm, or approximately three and a half to five years after planting.

The girth of each tree is measured at a height of 150 cm for budded clones and 75 cm for seedlings, from the ground level. Trees with girths of 45 cm and above are given three dots, less than 45 cm but more than 40 cm two dots and those below 40 cm but more than 35 cm one dot. Using black paint, the dots are placed on the tree trunks at the height of measurement. They are circular in shape of 1 cm in diameter arranged vertically at 0.5 cm apart *(Figure 9.10).* The census is repeated every three months until the trees with two dots and one dot attain the girth of 45 cm or more (three dots). Usually, tapping can commence when 70% of the stand attain 45 cm girth.

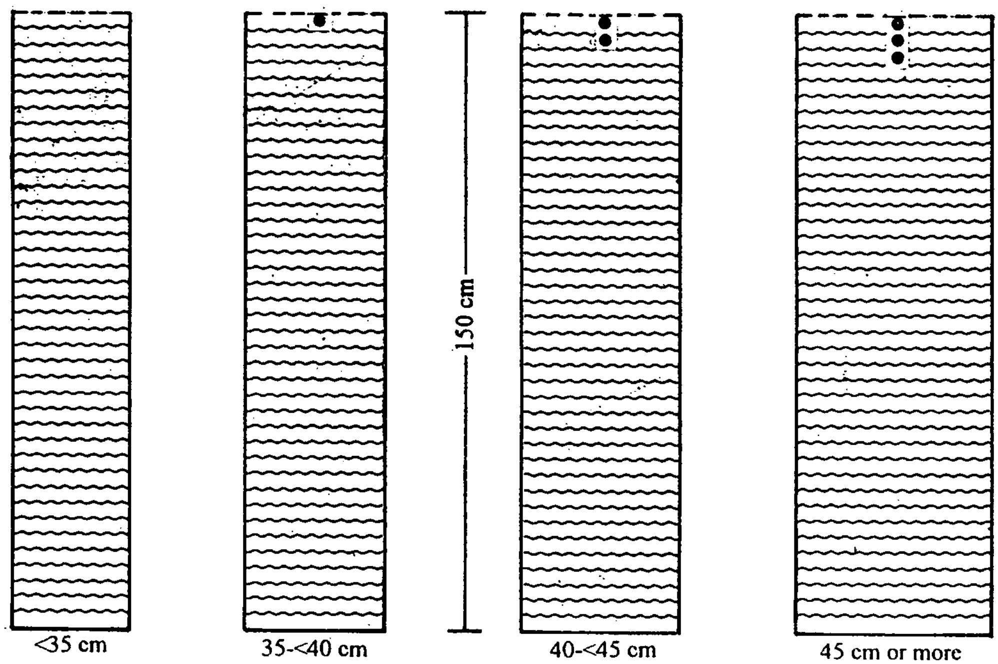


Figure 9.10: Girth size marking

OPENING OF TAPPING PANEL

Rubber trees are opened for tapping when their trunks have attained 45 cm girth, measured at a height of 150 cm for clones and 75 cm for seedlings from the ground level. In determining the maturity of the rubber tree, age is not considered; the most important factor being that the trunk has attained the required girth size, which is estimated to be in five years or less.

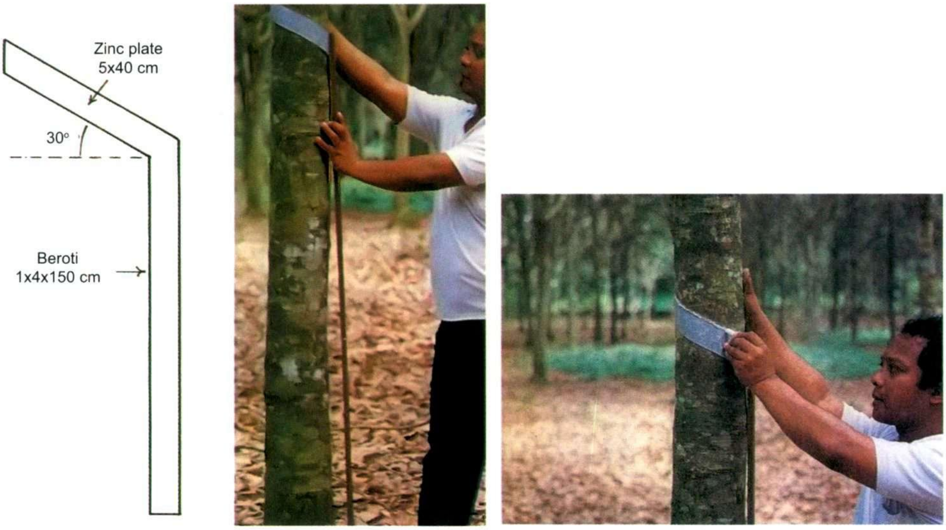
Girth Measurement

If tapping census or survey had been carried out earlier, trees with 45 cm girth sizes are already known. Otherwise, the girths have to be measured. This is done using a piece of wooden 'beroti' 150 cm in length with a piece of wire of 45 cm in length fixed at one end. The 'beroti' is placed upright against the tree trunk with the bottom end at ground level and the wire wrapped around the trunk. If the ends of the wire do not meet, the girth of the tree is taken as more than 45 cm. Each tree is measured in the same manner to determine the minimum 70% of trees for the opening of tapping. For the seedlings, the procedure is the same *(Figure 9.11)*.

Figure 9.11 Girth measurement

Marking the Slope of the Tapping Cut

To mark the tapping cut on the tree trunk, a template is required. This is done by using a piece of wooden 'beroti' of 150 cm in length for clones and 75 cm for seedlings, with a piece of zinc plate 40 cm long and 5 cm wide fixed at one end. The zinc plate is horizontally fixed at an angle of 30° for clones and 25° for seedlings. The 'beroti' is placed upright against the tree trunk with its bottom end at ground level and the zinc plate wrapped around the tree trunk towards the left. Using crayon or nail, a mark is made along the top edge of the template and continued down along the beroti right to the base of the trunk *(Figure 9.12)*. The tapping cut is made on half the circumference of the trunk. This is done by wrapping a piece of string around the trunk at 150 cm or 75 cm from the ground level, and folding it equally into two. The folded string is stretched across the trunk with one end at the corner of the slope and the left end of the string marked. This measurement is repeated at lower down the trunk to ensure that the trunk circumference is properly halved. A straight 'beroti' is placed against the tree trunk to meet both half circumference marks. Using crayon or nail, a mark is made along the 'beroti', from the top edge right down to the base of the trunk. The temporary panel border line that has already been marked on the trunk is then made permanent by a thin shaving of the bark along it, using the tapping knife. Using the rollmark, the amount of bark to be consumed monthly is marked out on the panel for the first eighteen months. To complete the operation, a spout, hanger and cup are fixed in position *(Figure 9.13)*.



(a) Template (b) Determining the slope (c) Marking the slope

Figure 9.12 Determining slope of tapping cut

(a) Measuring half trunk circumference

(b) Measuring half trunk circumference
at the bottom of the tree

(c) Shaving bark along slope

(d) Shaving bark along slope
and boundary marking

(e) Fixed spout, hanger and cup

Figure 9.13 Marking the tapping cut and opening of tapping panel

The spout is normally fixed at 20 cm below the tapping cut. This serves as an indication of a year's bark consumption for 1/2 Sd/3 tapping system. It is moved 20 cm downward again when the tapping cut reaches the spout. The spout should not be hit too hard into the wood to avoid damaging the cambium. The hanger is placed below the spout; the distance should be convenient enough to remove the latex cup without knocking the spout. Cup hangers with springs are preferred.

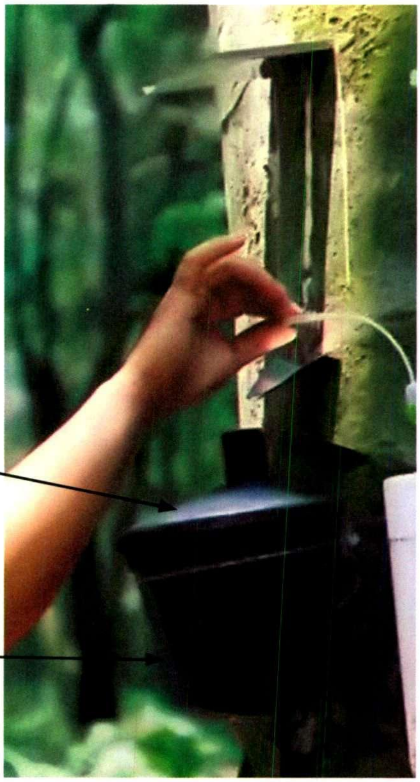
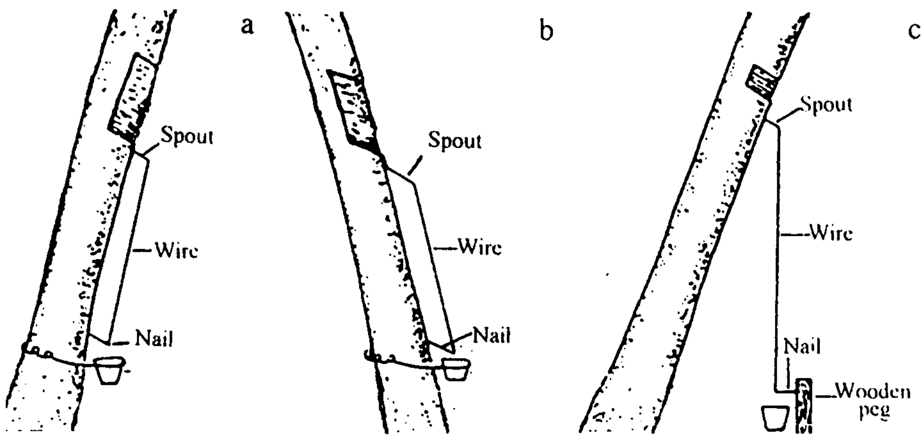


Figure 9.14 PVC latex cup fitted with lid and funnel known as RRIMCUP

Leaning trees are sometimes present in the plantation, especially in peat soil areas. Unlike in the case of the normal upright trees, there are certain procedures to be followed when leaning trees are opened for tapping. This is to prevent spillage of the latex. These procedures are illustrated in *Figure 9.16.*



(a) Leaning to the right (b) Leaning to the left (c) Too much leaning

Figure 9.15 Position of tapping panels and latex cups for leaning trees

TAPPING AND COLLECTION

Good tapping and collection procedures are essential to obtain maximum yield. In addition, cleanliness is also important in obtaining clean raw materials and finally high quality finished products.

Procedure of Tapping

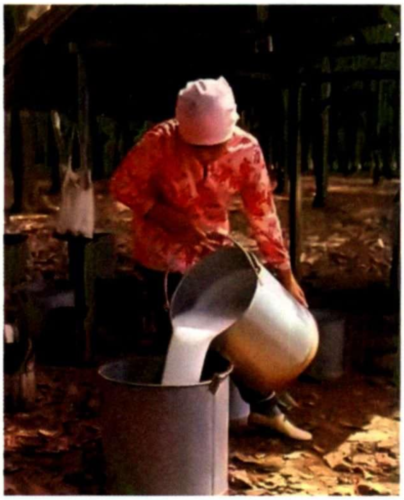
Tapping commences as early as possible in the morning. When the rubber tree is not in tapping, the latex cup should preferably be in the inverted position so that is does not collect dirt and water. Otherwise, the tapper must first clean the cup by removing scrap rubber and whatever foreign materials present in it. The cup is then replaced on its hanger in the inverted position. The tree lace is then removed from the tapping cut and spout, and placed in a special container. Using the sharp tapping knife, a thin slice of the bark is removed along the full length of the tapping cut until latex is seen oozing out. The cut of the bark must be deep enough without affecting the wood. The latex cup can now be put in its proper position for the latex to drip into it. The same procedure is applied to the rest of the trees. Tapping is carried on until all tappable trees in the task have been tapped (*Figure 9.16*). The latex is allowed to drip until it stops.

Figure 9.16 Tapping a rubber tree. A pulling cut is made right down to the bottom corner of the panel

Collection of Latex

Generally, latex is only collected when it stops dripping. This may take two to three hours, depending on various factors. Collection commences when the first few tapped trees cease dripping. During collection, the latex is completely scooped out of the cup and poured into the collecting bucket. The cup is then replaced on the hanger in the inverted position, unless late drip is anticipated. Collection is continued until latex from all tapped trees in the task is collected. The collected latex is immediately sent to the collecting centre or factory for processing. (*Figure 9.17*).

(a) Collecting of latex only when dripping stops



(b) Pouring latex completely into a collecting tank

Figure 9.17 Collection of latex

In tapping and collection, cleanliness must always be practised to avoid contamination of the latex. This can be achieved by ensuring that all pieces of equipment used, such as tapping knife, spout, cup, polybag, bucket and churn are clean. From time to time, the trees also need cleaning from moss and bits of dried bark. Scrap rubber collected in the field must not be mixed with the latex . The collected latex must always be kept covered. All these steps are necessary to avoid contamination of the latex with dirt and also to prevent the latex from precoagulation which makes further processing almost impossible. If necessary, anticoagulants are used to keep the latex in stable condition before processing.

EXPLOITATION SYMBOLS

Symbols can be defined as abbreviations of words, especially for the long ones. Exploitation symbols are abbreviations used for describing the methods of exploitation system. These symbols have been agreed to by the international rubber planting community, to facilitate communication. They were first introduced in 1939, but the complete set of symbols was established only in 1982 by the International Rubber Research and Development Board (IRRDB).

Cut Symbols

Tapping by cutting involves the operation of slicing away the bark to release the latex from the vessels. The symbols used are in the form of letters as shown below:

- S = Spiral cut
- V = V cut (a tapping cut in the shape of the letter V)
- C = Circumference cut (a tapping cut, the type of which is not specified)
- Mc = Mini cut (a tapping cut the length of which is less than 5 cm)

Length of Cuts

The length of a tapping cut is interpreted as the relative proportion of the trunk circumference that is embraced by the tapping cut and does not refer to the actual length. The length of cut is represented by a fraction before the symbol, except for a mini cut, the length of which is given in centimetres.

- S = One full spiral cut
- V = One full V cut
- C = One full circumference cut
- 1/2S = One-half spiral cut
- 1/3V = One-third V cut
- 3/4S = Three-quarter spiral cut
- 1/2C = One-half circumference cut
- Mc2 = Mini cut with 2 cm length
- SR = One full spiral cut 15 cm less than one full circumference

Number of Cuts

A number of tapping cuts can be made on a tree. These are either tapped on the same day or on alternate tapping days. The number of cuts is represented by a figure written before the symbols as shown below.

- 2x1/2S = Two half spiral cuts
- 3x1/2V = Three half V cuts
- 4xMc2 = Four mini cuts of 2 cm in length.

Frequency of Tapping

For the actual frequency, the symbol is a fraction of the time unit of day (d). The numerator of the fraction is d without any number before it and denotes the tapping period (day), while the denominator denotes the tapping interval of the actual frequency in days or in fraction of a day as listed below:

- d/1 = Daily
- d/2 = Alternate daily (one day in two)
- d/3 = Third daily (one day in three)
- d/4 = Fourth daily (one day in four)
- d/6 = Sixth daily (one day in six)
- d/0.5 = Twice daily

Fot the practical frequency, a fraction is written after the actual frequency, where continuous tapping is broken by regular day or days of rest. This fraction showing the frequency as a numerator as the number of days tapped in the period denoted by the denominator.

- d/1 2d/3 = Daily tapping , two days in tapping followed by one day of rest
- d/2 6d/7 = Alternate daily tapping, six days in tapping followed by one day of rest

Periodicity

The symbol of periodicity may consist of one or more fractions in the time unit of weeks (w), month (m) and year (y). The numerator of each fraction denotes the tapping period and may be with or without numeral before the symbol, while the denominator of each fraction denotes the length of the cycle (tapping period + rest). Each succeeding fraction in the periodicity symbol modifies the period of operation of the previous fraction, the denominator of the trial fraction gives the full cyclic period of the system.

- 2w/4 = Two weeks in tapping followed by two weeks of rest
- 6m/9 = Six months in tapping followed by three months of rest
- 2w/4 6m/9 = Two weeks in tapping followed by two weeks of rest during six months followed by three months of rest

Bark and Panel

The tapping panel is the area of bark where the tapping cut is made. The panel symbols describe the location of the panels and the type of bark as listed below:

- O = Virgin bark
- I = First renewed bark
- II = Second renewed bark
- III = Third renewed bark
- B = Base panel (150 cm and below)
- H = High panel (150 cm and above)
- BO-1 = Base panel, virgin bark, first panel
- BI-3 = Base panel, first renewed bark, third panel
- BII-2 = Base panel, second renewed bark, second panel
- HO-4 = High panel, virgin bark, fourth panel

Direction of Tapping

The direction of tapping can either be downward or upward. For tapping downward, no direction symbol is used. For upward tapping, an upward arrow (↑) sign is shown after the cut symbol. When two directions of tapping are applied on a tree, both direction symbols (↑↓) are shown after the cut symbols.

- ↓ = Downward tapping (usually not written)
- ↑ = Upward tapping
- ↑↓ = Upward and downward tapping
- 1/2 S = One half spiral cut tapped downward
- 1/4S↑ = One quarter spiral cut tapped upward
- 2x1/2V↑↓ = two half V cuts, one tapped upward and the other one tapped downward
- 3/4C1/2V↑1/4V↓ = Three-quarter circumference cut, one half V cut tapped upward and one quarter cut tapped downward.

Change-over System

Tapping may continuously be done on one panel or a group of panels, tapped on the same tapping day. It can also be done on several panels or on several groups of panels, each tapped on alternate tapping period. The latter is known as change-over system and is denoted by the cycle of changes of each tapping panel given within brackets. The first figure within brackets indicates the cycle of change of the second tapping panel. A comma (,) is inserted between a cycle of change of the tapping panels. The cycle of change tapping is denoted by the tapping panels. The cycle of change tapping is denoted by the symbol t (tapping), w (week), m (month) and y (year).

- (t,t) = Two cuts, each tapped alternately at every tapping
- (w,2w) = Two cuts the first tapped for one week followed by the second cut tapped for two weeks
- (6m, 6m) = Two cuts, each tapped alternately at every six month

Combination Tapping

Combination tapping describes the use of different length and types of cut on the same tree. Such tapping can be done on the same tapping day or on alternate tapping days.

When the trees are tapped by the combination tapping system on the same tapping day, the symbols for the system are joined by a plus (+) sign.

- 1/2S+1/4S ↑ = A half spiral cut downward, tapped on the same tapping day with a quarter spiral cut upward.
- 1/4S+1/4V = One quarter spiral cut downward, tapped on the same tapping day, with one quarter V cut downward.

When the trees are tapped by combination tapping on alternate tapping day, the symbols for the system are separated by a comma (,) sign.

- 1/2S,1/8S ↑ = One half spiral cut downward, tapped on alternate tapping day with one-eighth spiral cut upward.
- 1/4S,1/4V = One quarter spiral cut downward, tapped on alternate tapping day with one quarter V cut downward.

Stimulation Symbols

Stimulation also has its symbols in terms of active ingredients, concentrations, quantity applied, method and frequency of application. They also form part of the tapping symbols.

- ET = Ethephon
- ET 5.0% = Ethephon at five percent concentration
- Ba = Bark application
- Pa = Panel application
- Ga = Groove application
- La = Lace application
- m = Monthly application
- y = Yearly application
- 4/y = Four yearly applications

Examples of Full Exploitation System Symbols

- 1/2S d2

  One half spiral cut downward, tapped alternate daily

- 1/4 ↑ d/2 8m/12 ET5.0% 8/y
  One quarter spiral cut upward, tapped alternate daily for eight out of twelve months, stimulated with ethephon at five percent concentration, eight times a year.

- 1/4S d/1(t,t) 2d/3 8m/12 ET2.5% 2/y
  Two one quarter spiral cuts downward, tapped daily on alternate tapping two out of three days, eight out of twelve months, stimulated with ethephon at two and a half percent concentration, twice yearly.

- 1/4S ↑+1/2S d/3 ET5.0% 12/y
  Two cuts tapped on the same tapping day, one quarter spiral cut upward and one half spiral cut downward tapped third daily, stimulated with ethephon at five percent concentration, twelve times a year.

LATEX YIELD STIMULATION

Efficient latex harvesting systems are prerequisites to obtaining high and sustainable tree productivity, tapper productivity and land productivity with minimal deleterious effect on latex production and tree growth throughout the economic life of the *Hevea* trees. The most effective chemical as latex stimulant was found in the late sixties with the discovery of 2-chloroethylphosphonic acid that has the property of decomposing gradually in the presence of water, releasing ethylene gas as an active ingredient. In Malaysia, ethephon was introduced for commercial adoption in the early 1970s. In the late eighties, another development took place. A low intensity tapping system (LITS) concept was introduced to address low rubber production mainly because of tapper shortage, productive rubber areas left idle and low tree productivity, tapper productivity and land productivity issues. In general, LITS consists of exploitation systems with tapping intensity less than that of the conventional tapping system and where stimulation is one of the most critical components. Stimulation is a method to increase tapping yield of *Hevea* trees by prolonging latex flow with or without the use of chemicals. Increasing land to man ratio is an effective approach adopted in the LITS concept, to reduce the requirement of tappers and to increase tapper efficiency.

Subsequently, gaseous stimulation was developed and introduced to the NR industry during the 1990s in combination with "short cut" tapping system. At present, conventional ethephon stimulation has its limitations whilst gaseous stimulation is recommended only for 15 year-old and older *Hevea* trees where tapping on both BO-1 and BO-2 panels have been completed. The various latex stimulation techniques recommended by MRB are described in detail below.

Ethephon (ET) and Ethephon-Based Formulations

Ethephon

Currently, ethephon is intensively used and is mixed with carriers such as palm oil and water. Ethephon, through the ethylene it releases, delays the plugging mechanism in latex vessels, thereby enabling longer latex flow *(Table 9.5)*.

TABLE 9.5 EFFECT OF ETHEPHON STIMULATION ON YIELD

Clone	Tapping system	Panel	Period (year)	Yield (kg/ha)			
				Control	Bark	Groove	Lace
RRIM 600	1/2S d/2	BO-2	4	8,885	12,798	9,988	9,196
RRIM 701	1/2S d/2	BO-1	4	7,824	7,296	9,553	8,536
GT 1	1/2S d/2	BO-1	3	4,121	7,261	8,418	7,998
GT 1	1/2S d/3	BI-2	3	4,609	6,562	6,435	6,819
PB 5/51	1/2S d/3	BI-1	9	11,490	13,239	14,327	13,556
RRIM 623	1/2S d/3	BI-1	10	16,474	22,608	25,106	23,640
RRIM 605	1/2S d/3	BI-1	10	14,015	20,932	22,842	22,836

Note: Ethephon @ 5.0% was applied on the bark bi-monthly, on the groove and lace monthly.

The stimulant has to be in contact with the bark for a stated period of time to attain the effective response. Once a response has been initiated, immediate re-application of ethephon has no effect, except after a lapse of a few days between the first and subsequent application.

ET2.5% ET5.0% ET10%

Figure 9.18 Concentration of ethephon available in the market

Apart from that, weather also influences the effectiveness of ethephon. Moderate to heavy rain after application affects the yield response because it removes the stimulant from the site on the tree. Therefore, it is advisable to re-apply if it rains less than 6 hours after stimulation. Less frequent stimulant application is suitable for younger trees tapped on virgin bark and more frequently on older trees tapped on renewed bark and for upward tapping.

Ethephon is available in the market at concentrations of ET 2.5% (blue), ET 5.0% (green) dan ET 10% (red) *(Figure 9.18)*.

Method of Application

There are several methods of stimulant application. They are the bark, panel, groove, lace and the combined application methods. Brief descriptions of each method are given below.

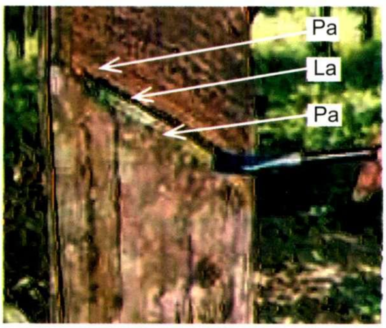
Bark application. A 3.8 cm strip of bark is scraped below the tapping cut just to remove the corky layer (no latex should ooze out), ethephon at 1.0-1.5 g is brushed on evenly over the scraped bark. The treated bark is tapped away within two months. *(Figures 9.20)*.

Panel application. Ethephon at 0.5-1.0 g is brushed on evenly over 1.25 cm strip of bark just above the tapping cut (*Figure 9.19*). Such application lasts for one month. This method can only be recommended if the panel is not to be retapped.

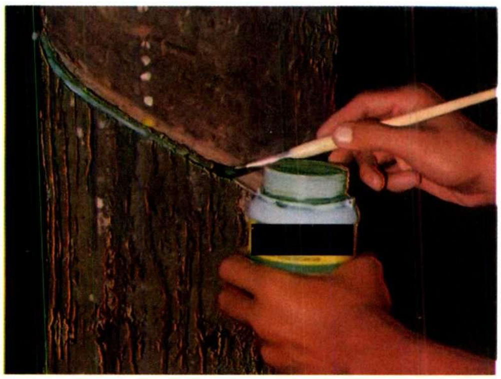
Groove application. After removing the thick tree lace, ethephon at 0.5-1.0 g is brushed evenly only over the tree lace along the tapping cut and part of the tapping panel (*Figure 9.20*). This application lasts for one month.

Lace application. Ethephon at 0.5-1.0 g is brushed on evenly over the tree lace along the tapping cut and part of the tapping panel (*Figure 9.19*). This application lasts for one month.

Bark and lace application. This combination method is specially recommended for trees tapped on the ultra low frequency tapping system of sixth daily (d/6). Ethephon is applied over the lace as usual and on a 6-mm strip of scraped bark below the tapping cut. A total of 1 g of stimulant is used per tree. The application also lasts for a month.



Stimulation by applying ET on the scraped bark (Ba), tapping slope (La) and tapping panel (Pa). Recommendation: For the Low Intensity Tapping System the tapping frequency is once every six days (LIT d/6).



Stimulation by applying ET on the rubber lace. Recommendation: For conventional tapping system (1/2S) with tapping intensity d/3 dan d/4.

Figure 9.19 Ethephon application techniques

Rate of Ethephon Usage

The rate of ethephon usage is between 0.5 to 1.0 g per tree for each application, except for the LIT d/6 system. For the LIT d/6 system, a higher amount is applied, i.e. between 0.75 to 1.5 g per tree. However, one should bear in mind that a higher rate of application, i.e. above the recommended amount will not give any incremental effect to the rubber yield since the yield is influenced by other activities such as tapping, physiology of the tree, chemical concentration and rate of application of ethephon.

Preparation of Low Concentration of Ethephon

Low ethephon concentrations such as ET 1.5% dan ET 3.3% are still not available in the market. 1.5 % ET concentration is recommended for young rubber trees which have recently been opened for tapping and for tapping on panel BO-1 *(Table 9.8)*. On the other hand, a 3.3% ET concentration is recommended for tapping on panel BI-1 while 5.0% ET for panels on BI-2 and HO. The items required for the preparation of ET 1.5%, 3.3% and 5.0% concentration are commercial ethephon (ET 2.5%, ET 5.0% dan ET 10.0%) and clean water.

TABLE 9.6 THE PREPARATION OF LOW CONCENTRATION ETHEPHON

Required concentration of ET (%)	Rate of mixing commercial ET with water	Number of trees that can be stimulated from 500 ml ET
1.5	ET 2.5%: Water (3:2)	800
2.5	ET 5.0%: Water (1:1)	1,000
3.3	ET 5.0%:Water (2:1)	700
5.0	ET 10%: Water (1:1)	1,000

Note: Concentration of ET 5.0% to ET 1.5% or ET 10% to ET 1.5% and ET 2.5% is not recommended since the concentration will be too thin and wil easily flow out from the tapping cut/groove.

Important Points to Remember:

i. The amount of ET 1.5%, ET 3.3% and ET 5.0%, must be prepared in accordance to the number of trees to be stimulated. For example, in the preparation of ET 1.5% for 500 trees: the amount of ET 2.5% required is 300 g while the quantity of water is 200 ml. Hence, one 500 g bottle of ET 2.5% can be reduced in concentration from ET 2.5% to ET 1.5% and applied for 800 trees.

ii. Low concentrations of ET (ET 1.5%, ET 3.3% and ET 5.0%) must be prepared on the same day just before application. It is not encouraged to keep prepared low concentrations of ET for the following next application.

iii. The chemical cost of low concentration ET for each application is less than or up to 1 sen. For example, assuming the cost of ET 2.5% is at RM 5.00 per 500 g bottle. Once the concentration is reduced to ET 1.5%, the cost of application per tree is 0.6 sen. In the case of ET 5.0% reduced from ET 10% concentration, the cost is 1 sen per tree (based on price of ET 10% at RM 10.00 per 500 g bottle).

Table 9.7 provides the guidelines for ethephon stimulation in terms of tapping system and schedule which need to be adhered to for optimum results.

TABLE 9.7 GUIDELINE FOR ETHEPHON STIMULATION

Panel	Tapping system	Stimulation schedule		
		Initial	Option	
			Option 1	Option 2
BO-1	1/2S d/2	ET 1.5% La 2/y	ET 1.5% La 3/y	ET 2.5% La 2/y
	1/2S d/3	ET 1.5% La 3/y	ET 1.5% La 4/y	ET 2.5% La 3/y
	1/2S d/4	ET 1.5% La 6/y	ET 1.5% La 8/y	ET 2.5% La 6/y
	1/2S d/6	ET 1.5% La 12/y	-	ET 2.5% La 12/y
BO-2	1/2S d/2	ET 2.5% La 3/y	ET 2.5% La 4/y	ET 3.3% La 3/y
	1/2S d/3	ET 2.5% La 4/y	ET 2.5% La 6/y	ET 3.3% La 4/y
	1/2S d/4	ET 2.5% La 8/y	-	ET 3.3% La 8/y
	1/2S d/6	ET 2.5% La 12/y	-	ET 3.3% La 12/y
BI-1	1/2S d/2	ET 3.3% La 6/y	ET 3.3% La 8/y	ET 5.0% La 8/y
	1/2S d/3	ET 3.3% La 8/y	-	ET 5.0% La 8/y
	1/2S d/4	ET 3.3% La 12/y	-	ET 5.0% La 8/y
	1/2S d/6	-	-	ET 5.0% La 12/y
HO-1 to HO-3	1/4S↑ + ET, 1/2S d/2-ns (8:4)	ET 5.0% La 8/y	-	-
1 year before felling	1/4S↑ + ET + 1/2S + ET or	ET 10% La 12/y	-	-
	1/2S↑ + ET + 1/2S + ET	ET 10% La 12/y	-	-

Option 1 : If the yield response is less than 10% of targeted yield (yearly)
Option 2 : If the yield response is less than 15-20% of targeted yield (yearly)

Clones That Respond Positively to Stimulation

Generally most of the RRIM 900 Series clones (except RRIM 921 and RRIM 916) give encouraging response to ethephon stimulation while the PB Series clones give less response. The PM 10 clone is categorised as giving medium response to ethephon. Clones such as RRIM 600, RRIM 605, RRIM 623, GT I dan PR 261 give medium to good responses.

Ethephon-Based Stimulant, *MORTEX*

MORTEX 2.5%

Increased and stabilised yield with MORTEX stimulated trees

Figure 9.20 Ethephon-based stimulant, *MORTEX*

In the year 2004, MRB launched an improved version of the ethephon-based latex stimulant (EBS) known commercially as MORTEX. The method of application is the same as that of ethephon but allows more frequent application (8-9 times/year) on young rubber right from the opening of tapping on panel BO-1 *(Figure 9.20)*.

Objectives

MORTEX is used to obtain higher stable yields with minimum side-effects especially for young rubber trees tapped on base panels. It can also be used for premium trees.

Application Technique

Figure 9.21 Applying *MORTEX* on the groove

MORTEX is applied on the groove along the tapping cut/slope covering <1.0 cm of the renewed bark on the upper end of the tapping slope using a suitable painting brush. (Only thick tree laces are to be removed prior to application) *(Figure 9.21)*.

Rate of *MORTEX* Application

The rate of MORTEX application is 0.5-1.0 g per tree. Any application above the recommended amount will not give any noticeable effect to latex yield. Hence, for economic and practical purposes, it is advised that MRB's recommendation is adhered to *(Table 9.8)*.

Important Points to Remember:

- In order to ensure continuous high yields, trees stimulated with *MORTEX* must be maintained and fertiliser applied according to schedule while adopting the recommended tapping system.
- Avoid using *MORTEX* during wintering months.
- Do not mix *MORTEX* with other chemicals.

Note:
Clones that give good response to ethephon give the same response to *MORTEX*.

TABLE 9.8 RECOMMENDATION OF *MORTEX* APPLICATION

Tapping panel	Frequency of annual application
BO-1	Six to eight times a year and rest during the wintering months
BO-2	Eight to nine times a year and rest during the wintering months
BI-1	Nine to ten times a year and rest during the wintering months

Gaseous Stimulation

RRIMFLOW (RF) and REACTORRIM (RR) are stimulation techniques applying the concept of supplying gaseous stimulant (ethylene gas) into laticiferous tissue of the rubber tree with different kinds of equipment. RF adopts intermittent gassing with supply of ethylene gas carried out every ten days while RR adopts a slow but continuous release of ethylene gas from a reactor bottle. The release of ethylene gas from the RR canister is regulated by a microporous membrane (MPM). Both stimulation techniques produce comparable tree productivity, approximately two to three times that of conventional tapping systems without any stimulation. These tapping systems are recommended for high tapping panels of premium *Hevea* trees (≥ 15 year old with both panels BO-1 and BO-2 already tapped) or older but are not suitable for younger *Hevea* trees, panels BO-1 and BO-2.

There are many types of old clones that respond favourably to this technique. Among them are GTI, RRIM 600, RRIM 623, RRIM 605, PB 261 and PB 217. Clones PB 28/59, PB 310 and seedling stocks are found to be less responsive to gaseous stimulation.

Currently MRB recommends three gaseous stimulation techniques using ethylene gas supplied directly into the laticiferous tissue of the rubber tree, viz. RR, RF and *G-FLEX* for trees that are 15 years old and above with both tapping panels (BO-1 dan BO-2) completely tapped. These trees must fulfill the following criteria:

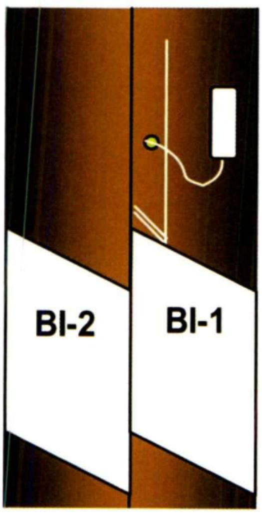
- Healthy
- Disease-free
- Adequate fertiliser application as recommended
- Clones that give positive response to ethephon
- Good bark on panel HO
- No indiscriminate tapping

Normally with the use of ethylene gas, the DRC drops by 2-5% due to the latex becoming more fluid compared to conventional system. The duration of the flow of latex will also be longer. The incidence of dryness is comparable to conventional tapping system.

REACTORRIM Stimulation Technique

REACTORRIM is a latex stimulation technique using ethylene gas from a reactor bottle supplied directly into the laticiferous tissue of the rubber tree gradually and continuously through the MPM. This stimulation technique is combined with 1/8 spiral short cut (1/8S) with d/3 or d/4 tapping frequency *(Figures 9.22-9.24)*.

The button is fixed 15 cm above the tapping panel in the centre between two tapping panels



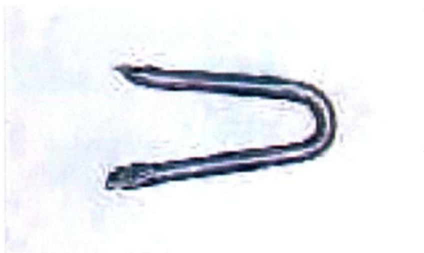
The canister is fixed 8 cm on the right hand side of the border of the tapping panel

The tapping panel is opened adjacent to the previous tapping panel with a 1/8 spiral tapping cut (10 cm)

Figure 9.22 REACTORRIM stimulation technique

REACTORRIM COMPONENTS

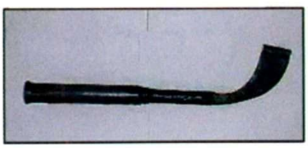
Button & canister bottle

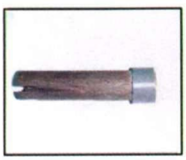


'U' Pin

ADDITIONAL GADGETS

Tapping knife





Button Fastener

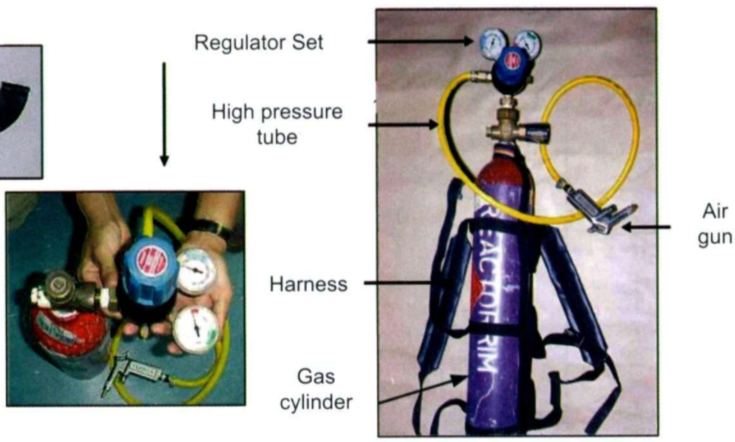


Figure 9.23 REACTORRIM components

Fixing Procedures of REACTORRIM

(i)

Open a 1/8 spiral tapping cut (1/8S) on the HO tapping panel above panel BI-1 or BI-2. Tap a few times on the groove until the desired depth is achieved. The tapping utensils should be fixed beforehand (1.2-litre collection cup, spring, hanger, spout). Tapping system : 1/8S↑ d/3, d/4 + REACTORRIM.

(ii)

Fix the button 15 cm above the 1/8 spiral tapping groove (Do not hit too hard and ensure that the button is securely fixed).

(iii)

Fix the 'U' pin, 7.5 cm to the right of the tapping panel of 1/8S and 15 cm above the earlier ½ spiral base panel.

(iv)

Hang the canister to the `U' pin (Ensure that the PVC tubing does not get entangled).

(v)

A completely fixed REACTORRIM set.

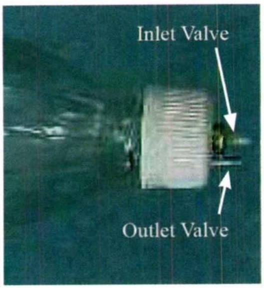
Figure 9.24 Fixing procedures of REACTORRIM

Note: The fixing of the REACTORRIM gadgets can be completed within 5 minutes/tree. The gas will be absorbed continuously into the bark as soon as step 3 is completed.

Recommendation: Tapping can be done after 48 hours or 2 days after step 3. Upon regassing, tapping is to be carried out 24 hours after that.

Regassing REACTORRIM Canister

(i)

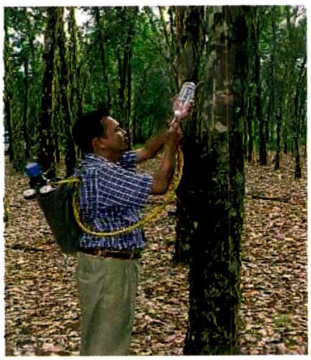


Place the nozzle of the air-gun to the inlet valve.

(ii)

Press the trigger of the air-gun to fill gas into the canister. Fill up with gas up to a pressure of 50 p.s.i. (The hissing sound stops once the pressure reaches 50 p.s.i.; approximately in 10 seconds and the canister becomes firm and feels warm).

(iii)



Remove the nozzle from the inlet valve.

(iv)

On completion of filling gas into the canister, the valve of the gas tank should be closed using a spanner.

Figure 9.25 Regassing the REACTORRIM canister

Important Points to Note (REACTORRIM):

i. During the initial stage, the pressure in the canister must not be more than 50 p.s.i. Avoid over-regassing into the canister.

ii. Check the MPM, for the following :
    - The content or pressure of the gas in the canister is lower than normal. Change the MPM if it does not function well.
    - The canister is still firm after 2-3 months. Change the MPM if it does not function well.

iii. If there is leakage of the plastic tube near the outlet valve, cut the portion away and refix it.

iv. Shift the button to a new position (≤ 15 cm above the 1/8S tapping groove) if it is found to be loose or its position is in an awkward manner resulting in leakage of gas.

RRIMFLOW Stimulation Technique

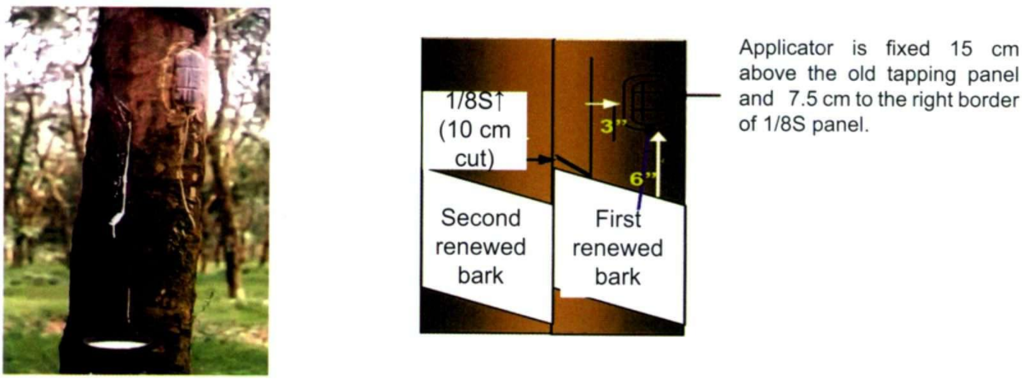


Figure 9.26 RRIMFLOW stimulation technique

RRIMFLOW is a latex stimulation method incorporating direct intermittent supply of ethylene gas into the bark of the rubber tree. This stimulation technique combines short cut tapping system that involves tapping panel of one-eighth circumferance (1/8S or 10 cm length) with low intensive tapping d/3 or d/4 and direct ethylene gas supplied every 10 days *(Figures 9.26-9.28)*.

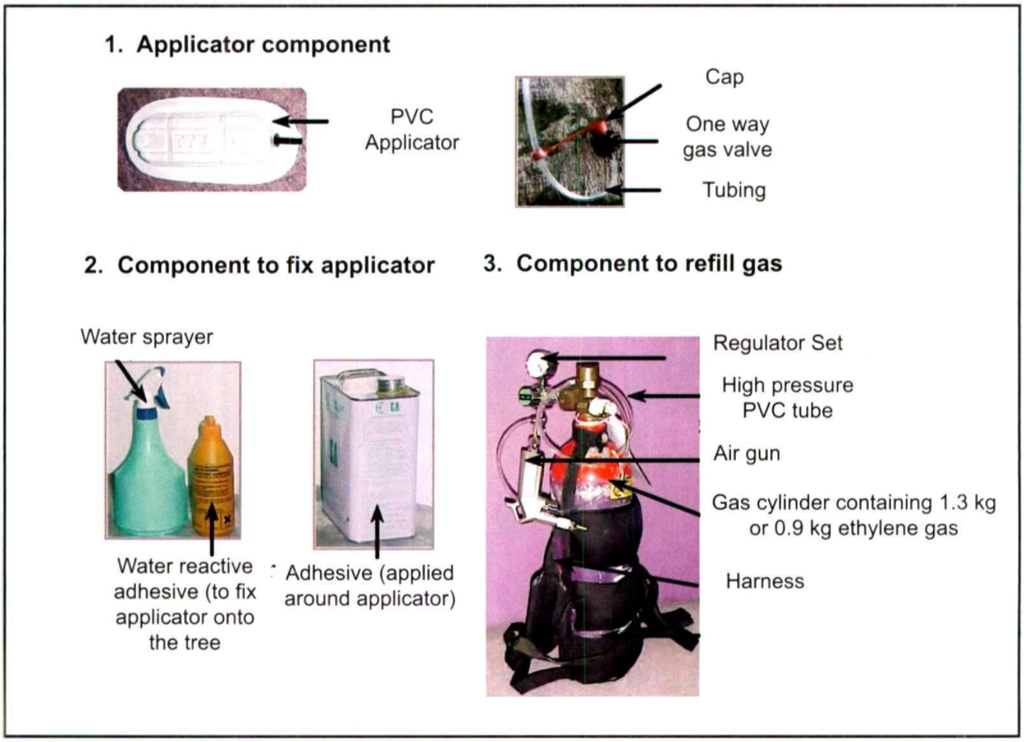
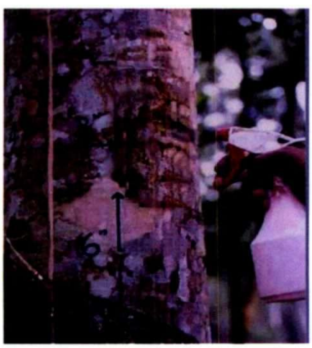


Figure 9.27 RRIMFLOW components

(i)

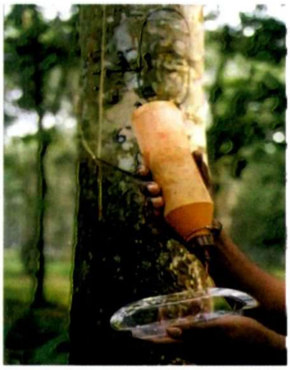
Open a tapping cut of 1/8 of the circumference (10 cm) on the high tapping panel (HO). Tap a few times on the groove until the desired depth is achieved.

(ii)



Clean the bark by scrubbing the area where the applicator is to be fixed i.e. 7.5 cm to the right of the 1/8S tapping panel and 15 cm above the old base tapping panel i.e. above the BI-2 (before this BO-2). After the bark is cleaned, spray water on the area to be fixed with the applicator. Tapping system : 1/8S d/3, d/4 + RRIMFLOW.

(iii)

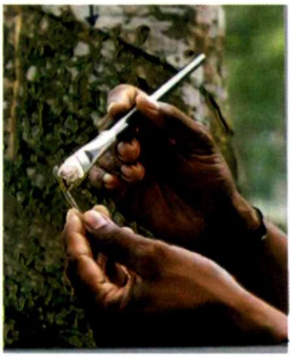


Apply water-reactive adhesive along the edge of the applicator and even it out with a clean stick.

(iv)

Place the applicator in the cleaned bark and staple it on. Make sure the edges of the applicator are properly sealed to the tree.

(v)



Cut a suitable length of PVC tubing (usually 60 cm) and apply a bit of contact adhesive at one end of it that has a slant cut.

(vi)

Insert PVC tubing (with contact adhesive) into the applicator valve.

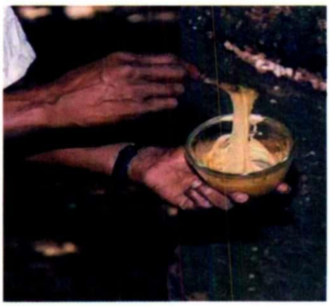
(vii)

Insert the cap holder through the PVC tubing followed by plugging the one-way valve to the end of the tube.

(viii)

Close the one-way valve with the cap with the PVC tubing forming a hook. Note : Steps (i) to (viii) to be done on the same day.

(ix)



The next day, prepare a mixture of contact adhesive (EA gum) and latex between ratios 99:1 and 9:5. Note : One tin of contact adhesive (EA gum) can be used for up to 400 applicators.

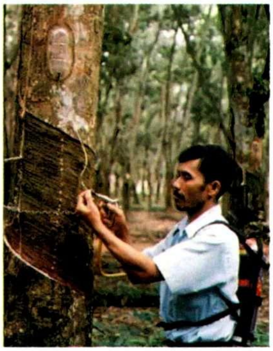
(x)

Apply the contact adhesive (EA-gum) and latex mixture on the edge of the applicator. Ensure the edge of the applicator is properly sealed to the bark of the tree. Let the adhesive/latex mixture to cure between 24-48 hours.

Figure 9.28 Fixing procedures of RRIMFLOW

Gassing for RRIMFLOW

(i)

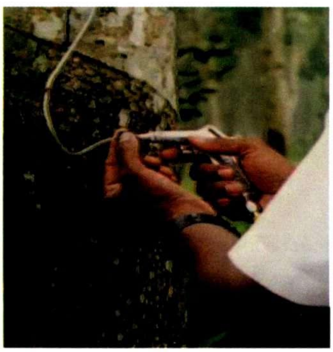


Gas cylinder is carried using a harness.

(ii)

Remove the cap of the one-way valve with a slight turn.

(iii)



Insert the nozzle into the one-way valve. Apply a pulse of gas into the one-way valve by pressing and releasing immediately the trigger of the air gun. Replace cap of one-way valve. One pulse is sufficient for one tree. One cylinder of gas is sufficient for approximately 15,000 trees.

Figure 9.29 RRIMFLOW gassing procedures in the field

Important Points to Note (RRIMFLOW):

i. After each installation, the first tapping is only carried out 48 hours after gassing into the applicator. Subsequently, tapping is done 24 hours after gassing.

ii. Ensure that there is no leakage at the applicator. Usually it occurs between the applicator and the bark of the tree.

iii. If minor damage is done to the applicator by insects or animals it can be repaired by sealing with masking tape and adhesives. But if the damage is beyond repair, then, the applicator is to be replaced with a new one.

iv. If leakage is detected at the sides of the applicator, apply a mixture of adhesive and latex on it. Maintenance of the applicator has to be carried out at least twice a year (i.e. resealing). It is recommended that applicators be checked for leakage regularly, e.g. once in two months.

v. It is advisable to detach the PVC tube from the one-way valve at the second tapping. This is to ensure that water does not accumulate at the applicator and this will also help in differentiating the gassed trees from the non-gassed trees.

vi. During the wintering months, there is no stimulation. Tapping is reverted to the normal base panel until the wintering period is over.

vii. To overcome the problem of volatile fatty acid (VFA), second collection has to be done so as to not to leave any residual latex in the cups or else add preservatives or coagulants such as ammonia or TMTD/Zno solution into the latex cups after tapping.

***G-FLEX* Stimulation Technique**

G-FLEX which is a more user-friendly stimulation device, especially in terms of fixing and maintenance. It is an improved gaseous application technology combining several criteria from the RR and RF technology. This technology was developed to encourage more users, specifically the individual smallholders, to adopt gaseous stimulation. It was launched in 2004 by MRB.

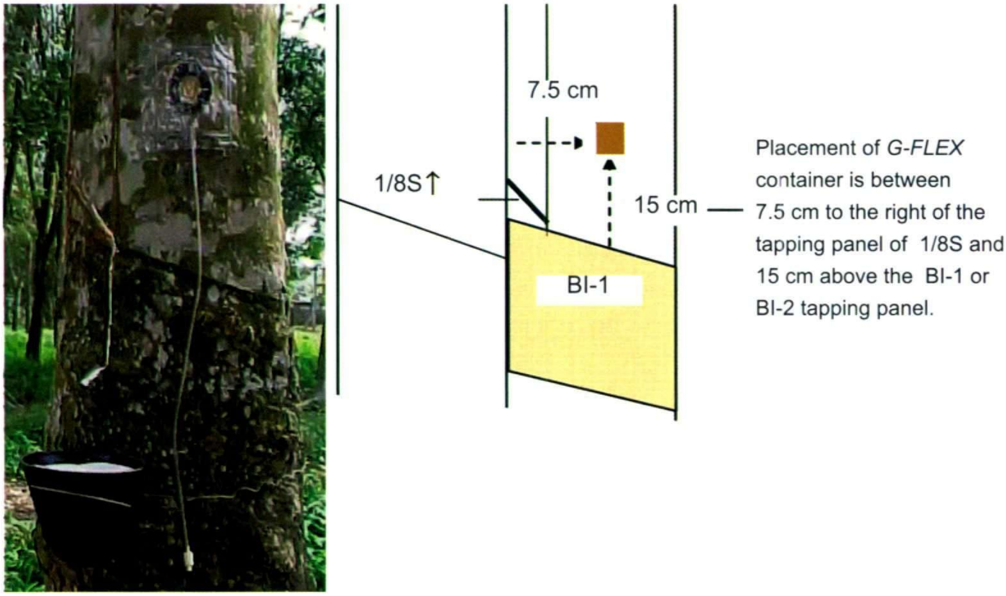


Figure 9.30 *G-FLEX* and its placement

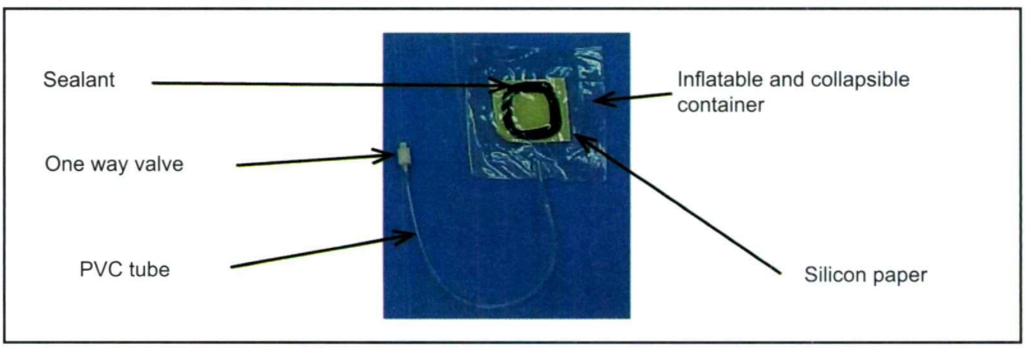


Figure 9.31 Components of *G-FLEX*

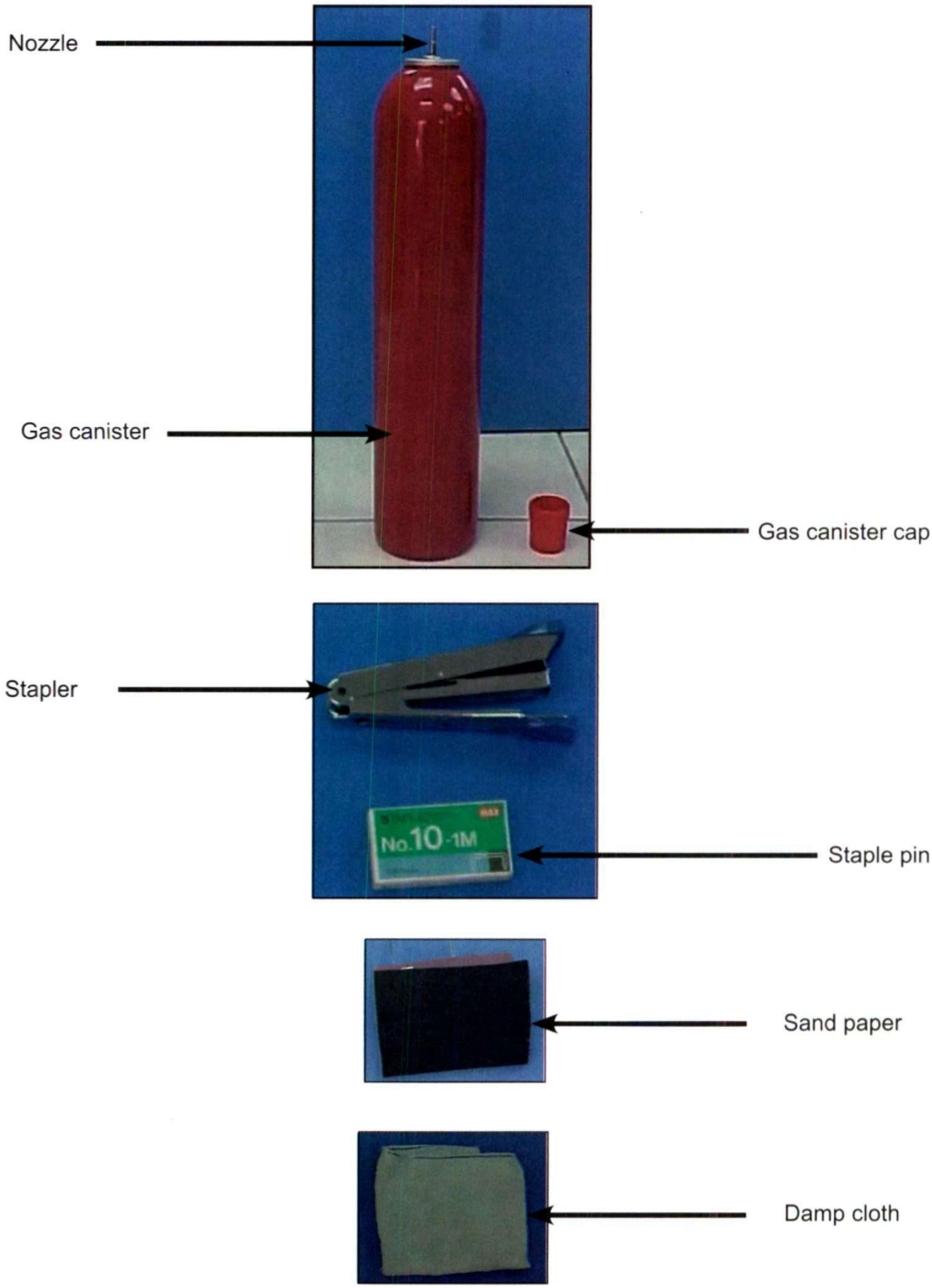


Figure 9.32 Additional components *(G-FLEX)*

Procedures of Fixing G-Flex

(i)

Open a tapping cut of 1/8 of the circumference (10 cm) on the high tapping panel (HO). Tap a few times on the groove until the desired depth is achieved.

(ii)

Clean the bark surface of flakes and dirt and wipe the area where the G-Flex is to be placed (7.5 cm to the right of the tapping panel of 1/8 S and 15 cm above the BI-1 or BI-2) with a damp cloth.

(iii)

Remove the *G-FLEX* cover (silicon-coated paper).

(iv)

Once the bark surface has dried, place *G-FLEX* appropriately and press onto the sealant evenly.

(v)

Blow into container until it is well-expanded to check for leakage.

(vi)

Side view of well-expanded *G-FLEX*.

(vii)

Staple each corner while the container is still in expanded shape.

Figure 9.33 Procedure of fixing *G-FLEX*

Gassing procedure for G-Flex

(i)

Remove the one-way valve.

(ii)

Empty the container by pressing and releasing the air slowly.

(iii)

Re-attach the one-way valve to the delivery plastic tubing.

(iv)

Fill in the gas.

(v)

Gas is filled into the container slowly until full (expanded) once in every 10 days. Each canister of gas is sufficient for gassing up to 2,000 trees. Tapping to be carried out 48 hours after the first installation and gassing. Subsequent tappings could be done 24 hours after each re-gassing.

Figure 9.34 Procedure of gassing in the field

Do-it-Yourself (D.I.Y.) Maintenance Technique of G-Flex

(i)

If wrongly placed or sign of gas leakage suspected or slightly damaged, remove *G-FLEX* from the tree and detach the sealant. (*G-FLEX* sealant is re-usable)

(ii)

Re-use the container (If badly damaged get a new container)

(iii)

Re-shape the sealant to its original form.

(iv)

Place the sealant back properly and re-attach the container on the tree

Figure 9.35 Do-It-Yourself techniques of *G-FLEX*

Characteristic of *G-FLEX*

- User friendly
  - method of fixing has been simplified due to simple gadgets used.
- Easy to manage and maintain
  - the most critical aspect of maintenance is pressing the sealant before re-gassing.
- Flexible
  - *G-FLEX* can be used on high tapping panels combined with a short tapping cut and tapped on d/3 or d/4 tapping frequency. The sealant allows *G-FLEX* to be repositioned without changing the components. The formulation allows the sealant to accommodate the growth expansion which reduces the problem of gas leakage and maintenance of the components of *G-FLEX*.
- Do-it-yourself (D.I.Y.)
  - users can fix the *G-FLEX* components on their own.
- Gassing
  - simplified method of gassing.

Important Points to Note (G-Flex):

(i) Presently, all gaseous stimulation techniques i.e. RRIMFLOW, REACTORRIM and G-FLEX, are recommended for application to premium rubber trees only (i.e. 15 years and above with both panels BO-1 and BO-2 consumed).

(ii) The tapping system recommended is 1/8S↑ d/3, d/4 with upward opening of tapping panel (HO). The gaseous stimulation technique produces optimum yield when combined with the 1/8S↑ d/3, d/4 tapping system. Longer cuts do not result in increase of yields.

(iii) At the initial stage, the rubber tree is tapped 48 hours or 2 days after gassing is done. After that, the tree can be tapped 24 hours or one day after gassing.

(iv) It is very important to make sure that there is no leakage of gas at the container or button as this may result in a drastic reduction in yield.

(v) The proper installation, scheduled tapping, regular gassing and maintenance as recommended coupled with good agronomic practices are very important factors in obtaining high yields in rubber.

CONTROLLED UPWARD TAPPING

High panels, especially on trees with straight clean stems (without branches) up to the height of 3 m, can provide additional areas of bark panel which is equally important in terms of yield. If the high panels are to be tapped downward, a ladder has to be used and this creates additional burden to the tapper. A bark island will also be formed, where eventually, as the tapping goes down, the yield gets lesser and lesser. This is because the latex vessels have been severed and the vessel network is being cut off. Therefore, the bark has to be tapped upward, using a modified tapping knife. Actually, upward tapping had been practised since the 1950's. Due to various problems encountered, the technique became unpopular and later abandoned. The upward tapping technique described in this chapter is the controlled upward tapping (CUT), which is an improvement of the old one. It is controlled in respect of the slope of the tapping cut and the bark consumption.

The Tapping Knife

The knife is a modified gouge, with V-shaped blade of 60° angle. The width of the blade is 1.8 cm, tapering inward of 60°. The length of the blade is about 10 cm and bent away from the handle at 30°. It is fitted to a wooden handle, the length of which depends on the height of the tapping cut *(Figure 9.36)*.

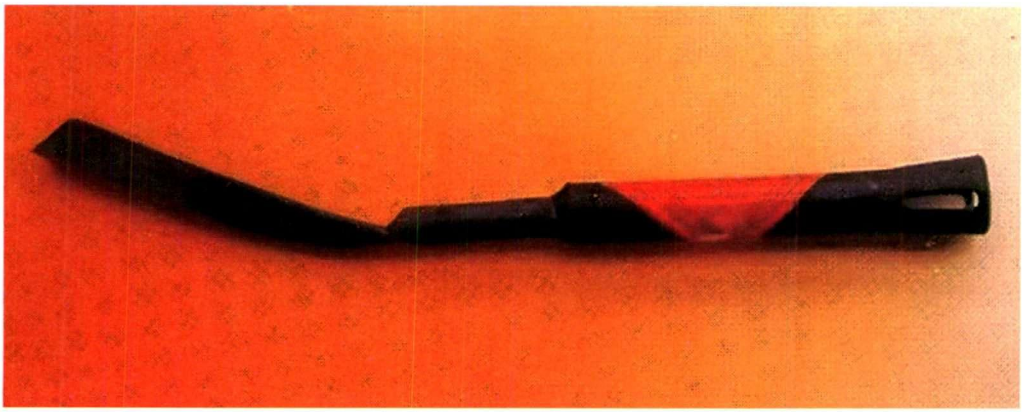
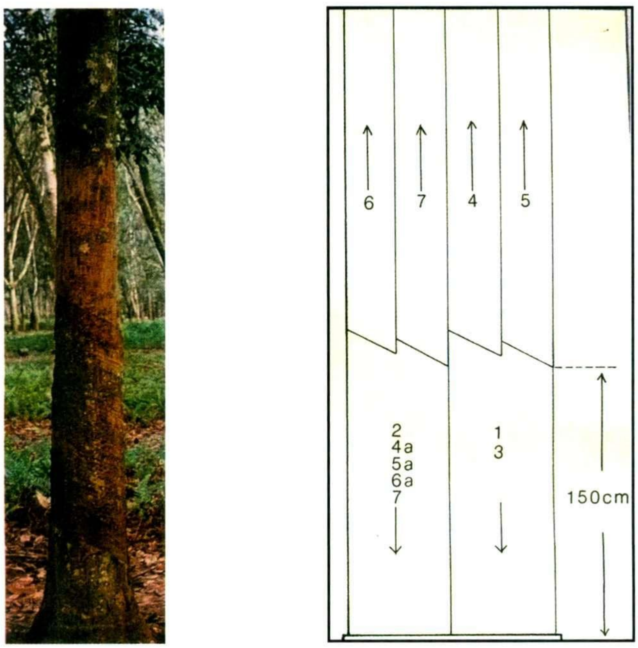


Figure 9.36 The controlled upward tapping (CUT) knife

Opening of the Tapping Panel

Controlled upward tapping can commence when tapping on panel BI-1 has been completed. Its first panel (HO-1) is opened at 1/8 S, 150 cm from the ground level and in line with panel BI-1. The angle of slope is 45° to effect a faster flow of the latex along the cut. Four panels can be obtained from the trunk circumference (HO-1, HO-2, HO-3 and HO-4) to be tapped up to a height of 3 m at approximately two years per panel.

To open the first panel, a vertical cut 60 cm long is made above the lower panel which has just been fully tapped. A string is wrapped around the trunk and folded equally into four. The four-folded string is stretched across the trunk to obtain a quarter circumference, and the right end of the string is marked. Another vertical cut is made on the bark 60 cm long at this quarter circumference mark. A pre-prepared 45° template is placed over the trunk with its right edge in line with the right vertical cut, and the template is wrapped around the trunk towards the left. Using crayon or nail, a mark is made along the top edge of the template. A 45° slope is now marked on the trunk. The bark along the marked slope is tapped away. This is repeated several times until a 2.5 cm panel is opened to fit in the blade of the controlled upward tapping knife. Then, an upward cut is made on the upper cut of the panel using the upward tapping knife. A spout, hanger and cup can now be fixed on the tree. Using the rollmarker, the bark to be consumed monthly can be marked for eighteen months' consumption. Ethephon at 5.0% is applied along the groove of the tapping cut. The tree is ready for upward tapping the following day *(Figure 9.37).*



(a) Tree suitable for CUT

(b) CUT panel succession

Figure 9.37 CUT system for the upper panel

(a) Marking panel boundary lines

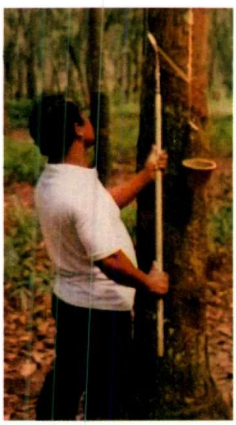
(b) Measuring one quarter circumference

(c) Marking the slope

(d) Opening the strip for CUT

(e) Marking tapping groove using the CUT knife

(f) Applying stimulant on tapping slope



(g) Tapping with CUT system

(h) Latex allowed to drip into cup

(i) As tapping panel get higher latex flow need to be guided by using fine wire

Figure 9.38 Opening of controlled upward tapping (CUT) panel

Technique of Tapping

To tap the tree, the tapper stands facing the tree where the upward panel is located. His feet are 30 cm apart and 45 cm away from the base of the tree. His left hand holds the upper part of the wooden handle gently, while his right hand grips the lower end of the handle to push the knife. Starting at the right lower corner of the tapping cut, the blade is pushed into the bark, slightly tilting the inner blade away from the panel to avoid wounding it. The cutting is continued and when it reaches half way along the cut, his right leg is lifted off the ground passing behind his left leg. At the same time the cutting is continued to reach the left hand corner of the tapping cut and his left leg is simultaneously moved to the left. The whole tapping cut is completed in two steps only. Throughout the tapping operation, both the tapper's arms must be below the shoulder level to prevent tiredness. The latex should be guided to flow along the cut and the vertical channel to avoid spillage (*Figure 9.38*). The depth of tapping is as usual, but the thickness can be slightly more than the downward tapping, and 25-30 mm per month on alternate daily is permissible.

After some time, the tapping cut gets higher and higher and there can be difficulty in getting the latex into the cup. This can be overcome by fixing two spouts, connected by a tightly fixed piece of fine wire or tree lace.

Ethephon stimulant is applied along the lace monthly. Upward tapping with a quarter cut does not yield well without stimulation. As stimulation is not recommended during the wintering months, tapping should be on panel BI-2 without stimulation. When panel HO-1 is completed, tapping should be changed to panel HO-2 and so forth until the whole trunk circumference above 150 cm is completely tapped.

Controlled upward tapping of high panels generally gives much higher yields than downward tapping, at the same time doing away with the ladder climbing system. However, there are variations in clonal responses to yield *(Table 9.9)*. Tapping the high panels also results in longer economic life of the trees.

TABLE 9.9 CLONAL RESPONSE ON YIELD FROM CONTROLLED UPWARD TAPPING

Response	Clone
Good (> 50%)	GT1, RRIM 600, RRIM 614, RRIM 605, PR 107 and RRIM 501
Moderate (30-50%)	RRIM 623 and PB 5/51
Poor (<30%)	LCB 1350 and Tjir 1

TASKING AND RETASKING

The number of trees allocated to a tapper for tapping within a specified time, usually a day's work, is called a tapping task. The work of allocating the task is known as tasking, while retasking means reorganising or reviewing existing tasks.

Approach to Tasking

The size of a tapping task is based on a number of factors, namely, the planting density per hectare, topography of the area, size of the tree trunks and length of the tapping cut. A very high task size gives higher yield to the tapper but a lower yield to the hectare basis. This is because the tapper takes a much longer time to complete his task and therefore quite a large number of trees are tapped during the late morning. A very low task size results in the tapper completing his task early, thus higher yield to the hectare basis, but lower yield to the tapper. The number of tappers required is also high, which can also lead to higher tapping cost *(Table 9.10).*

The number of tappers required for a particular area can be calculated by the following formula :

$$\text{Number of Tappers Required} = \frac{\text{Planting density per hectare x size of the area (ha)}}{\text{Frequency of tapping x task size}}$$

Example :

Planting density per hectare	=	480 trees
Size of the area	=	100 ha
Frequency of tapping	=	d/3
Task size (per tapper)	=	600 trees
	=	$\frac{480 \times 100}{3 \times 600}$
	=	27 tappers

The area (ha) covered by each tapper can also be calculated by the following formula:

$$\text{Area Covered} = \frac{\text{Frequency of tapping x task size}}{\text{Planting density per hectare}}$$

Example:

Frequency of tapping	=	d/3		
Task size (per tapper)	=	600 trees		
Planting density per hectare	=	480 trees		
Area covered per tapper	=	$\frac{3 \times 600}{480}$		
	=	3.75 ha	=	3.8 ha

TABLE 9.10 MAPA-NUPW TAPPING TASK SIZES

Topography of area	Height of tapping	Length of tapping cut	Years of tapping					
			< 5	5-10	10-15	15-20	20-25	>25
Flat and undulating	Low	1/2S	600	575	530	510	465	450
		S/R	552	529	488	469	428	414
		S	480	460	424	408	372	360
	High	1/2S	390	374	345	332	302	293
	High and low	1/2S or 1/2V and 1/2S	-	-	225	217	198	191
		1/2S or 1/2V and S	-	-	201	194	177	171
Terraced hill	Low	1/2S	564	541	498	479	437	423
		S/R	519	497	459	441	402	389
		S	451	432	399	384	350	338
	High	1/2S	371	355	328	315	287	278
	High and low	1/2S or 1/2V and 1/2S	-	-	218	210	192	185
		1/2S or 1/2V and S	-	-	195	188	172	166

Note: Where upward tapping is carried out without the use of the ladder, the task size is 90% of the normal task tapped downward.
For hilly areas where the terraces are less than a metre wide, the task size must be agreed upon at the plantation level. For special or experimental tapping, the task size is also to be agreed upon at plantation level.

Method of Tasking and Retasking

Tasking can become simpler if a particular area or plantation has a point plan prepared during the development stage. If there is none, the whole area that is to come under tapping must be thoroughly studied for this purpose. There must be separate tasks for the flat and hilly areas. If possible, all tasks must have a road frontage to facilitate latex collection. For a flat area, the allocation of tasks must be according to the row, while for the hill slopes according to the terraces. Avoid roads, rivers, streams and swamps from separating tasks. They should be used as boundaries for the tasks instead. Task boundaries must be clearly marked with task numbers painted on the border trees.

Retasking may be necessary from time to time. This takes place when more new trees come into tapping or there is a reduction in density due to losses by diseases or pest attacks or other physical injuries. Sometimes, a change in the tapping system also necessitates the existing task size to be reviewed.

TAPPING SYSTEMS

A tapping system refers to the manner in which a rubber tree is exploited. It consists of the length and type of cut, frequency of tapping and stimulation. All these are given in symbols. The following are a number of tapping systems and their descriptions, which have been in use in Malaysia.

1/2S d/2

Half spiral tapping cut, tapped alternate daily. This has been the most popular tapping system. It is suitable on most clones, except those susceptible to brown bast or tree dryness. The annual bark consumption for this system is 20-25 cm. Yield obtained is high. This system is considered optimum in terms of growth, yield, tapping cost and bark renewal.

1/2S d/3

Half spiral tapping cut, tapped third daily. This system is grouped under the low frequency tapping system. It is suitable for seedling materials and clones susceptible to brown bast, and in areas where there is shortage of tappers. Yield is about 85% of 1/2S d/2. The annual bark consumption is 18-25 cm. The DRC of latex obtained is slightly higher, while the tapping cost is 15% lower than 1/2S d/2. A tapper can tap more trees using this system, hence less tappers are required. Stimulation is required to level up its yield with 1/2S d/2.

1/2S d/4

Half spiral tapping cut, tapped fourth daily. This system is also a low frequency tapping system. It consumes 15-20 cm of bark annually. The yield is lower and must be enhanced with stimulation. The DRC of latex is much higher. It is designed for areas where there is shortage of tappers, as a tapper using this system can tap 100% more trees compared to 1/2S d/2. Tapping cost is much lower.

1/2S d/6

Half spiral tapping cut, tapped sixth daily or once a week. This is an ultra low frequency tapping system, specially designed for the period of acute shortage of tappers. A tapper can handle six tapping tasks with this system. Studies have shown that there is a difference in yield response according to clones. The good response in yield is only obtained by the modified method of stimulant applications, which is the lace combined with the bark application. This system requires the bark to be tapped up to 3 mm per tapping due to the dry bark tissue during the long rest between tappings. The monthly bark consumption is approximately 15 millimetres. It is best to start on this system from commencement of tapping. However when trees have been subjected to high frequency tapping of d/2 to d/3, d/4 and d/6 over a period of one to two years and if the present cut is nearing the ground level (30 cm and below), start on a new panel when changing to low frequency.

1/2S d/2 9m/12

Half spiral tapping cut, tapped alternate daily for nine months, followed by three months of rest. This system is known as the periodic tapping system. Using this system, a tapper can handle a larger tapping area.

1/2S d/3 9m/12

Half spiral tapping cut, tapped third daily for nine months, followed by three months of rest. The number of tasks that can be handled by a tapper with this system of tapping is higher. The three months rest to the trees in a year reduces tapper requirement by 25%. There is also a good deal of reduction in bark consumption. Yield of PB 235 and PR 255 on this system is comparable to 1/2S d/3.

Other Alternative Systems

Actually there is no perfect single tapping system suitable to all rubber trees. Tapping systems are recommended according to clones and ground situations. The current tapping systems are geared towards the low frequency ones, such as d/3, d/4, d/6, periodic and even the Division of Labour (DOL) system where a tapper only carries out tapping, while collection of latex is done by other workers. This enables a tapper to tap up to two tasks a day, thus overcoming shortage of tappers.

EXPLOITATION SCHEDULES

Exploitation schedules can be defined as the systematic procedures and stages of harvesting the latex yield of the rubber trees, panel by panel, from the time tapping commences up to the completion of the tapping cycle. A full exploitation schedule takes around thirty years to complete, and this time period is considered as the economic life of the rubber tree.

Schedule and Systems

Seven exploitation schedules are suggested, six are for clones and one for clonal seedling materials. The first one *(Table 9.11 and Figure 9.40)* describes the normal standard exploitation schedule for buddings with a panel-changing system *(Table 9.12 and Figure 9.41)* as an alternative. To reduce bark consumption in smallholdings, a third system *(Table 9.13 and Figure 9.42)* is suggested, while the panel-changing system *(Table 9.14 and Figure 9.43)* is given as an alternative. The fifth and sixth *(Tables 9.15 and 9.16 and Figure 9.44)* are low frequency schedules specially designed for areas with acute shortage of tapping labour. *Table 9.17* and *Figure 9.45* is a schedule for exploitation of clonal seedling materials.

TABLE 9.11 EXPLOITATION SYSTEM FOR BUDDINGS (I)

Phase (*Figure 9.39*)	Tapping panel	Tapping system			
		All clones	Period (year)	Brown bast clones	Period (year)
I (a)	BO-1	1/2S d/2 ET2.5% 2/y	6	1/2S d/3 ET2.5% 2/y	7
II (b)	BO-2	1/2S d/2 ET3.3% 4/y	6	1/2S d/3 ET3.3% 4/y	7
III (c)	BI-1	1/2S d/2 ET5.0% 4-6/y	5	1/2S d/3 ET5.0% 4-6/y	6
IV (d)	HO-1,	1/4S↑ d/2 8m/12 ET5.0% 8/y	2	1/4S↑ d/3 8m/12 ET5.0% 8/y	2.5
	BI-2	1/2S d/2 4m/12 ET5.0% 1/y*		1/2S d/3 4m/12 ET5.0% 1/y*	
V (e)	HO-2	1/4S↑ d/2 8m/12 ET5.0% 8/y,	2	1/4S↑ d/3 8m/12 ET5.0% 8/y	2.5
	BI-2	1/2S d/2 4m/12 ET5.0% 1/y*		1/2S d/3 4m/12 ET5.0% 1/y*	
VI (f)	HO-3	1/4S↑ d/2 8m/12 ET5.0% 8/y,	2	1/4S↑ d/3 8m/12 ET5.0% 8/y,	2.5VI
	B1-2	1/2S d/2 4m/12 ET5.0% 1/y*		1/2S d/3 4m/12 ET5.0% 1/y*	
VII (g)	HO-4+BI-2	1/4S↑ +1/2S d/3 ET5.0% 12/y	2.5	1/4S↑ + 1/2S d/3 ET5.0% 12/y	3
Total			25.5		30.5

*Tapping system during wintering period
Except in phase I, throughout the tapping schedule up to phase III, the use of stimulant is on staggered basis (1/2:1/2), phase IV onwards to all trees and on both cuts during the final phase VII.

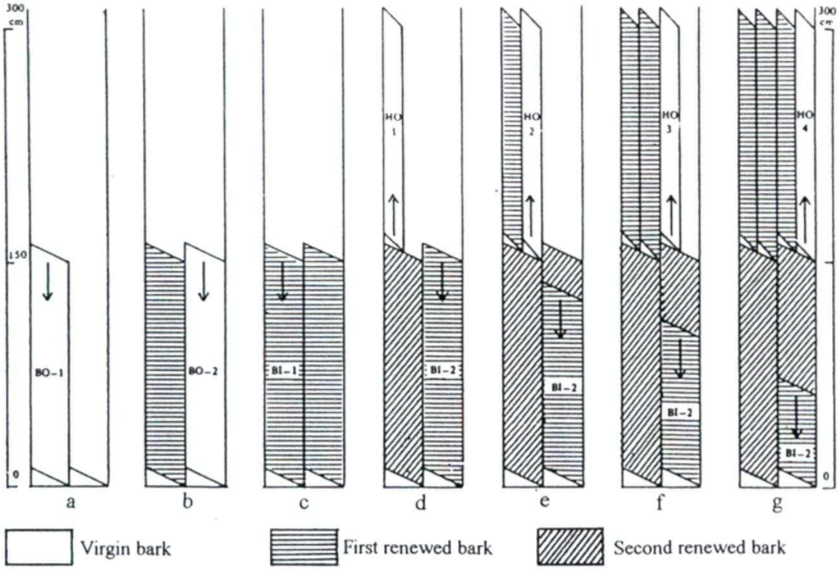


Figure 9.39 Succession of tapping panels for buddings (I)

TABLE 9.12 EXPLOITATION SYSTEM FOR BUDDINGS (II)

Phase *(Figure 9.40)*	Tapping panel	Panel-changing tapping system for all clones except those prone to brown bast	Period (year)
I (a)	BO-1, BO-2	1/4S d/2 (t,t) 8m/12 ET3.3% 4/y,	8
	BO-1&BO-2	1/2S d/2 4m/12*	
II (b)	BO-3, BO-4	1/4S d/2 (t,t) 8m/12 ET5.0% 4/y,	8
	BO-3&BO-4	1/2S d/2 4m/12*	
III (c)	BI-1, BI-2	1/4S d/2 (t,t) 8m/12 ET5.0% 6/y,	8
	BI-1&BI-2	1/2S d/2 4m/12*	
IV (d)	HO-1,	1/4S↑ d/2 8m/12 ET5.0% 8/y,	2
	BI-3&BI-4	1/2S d/2 4m/12 ET5.0% 1/y*	
V (e)	HO-2	1/4S↑ d/2 8m/12 ET5.0% 8/y,	2
	BI-3&BI-4	1/2S d/2 4m/12 ET5.0% 1/y*	
VI (f)	HO-3	1/4S↑ d/2 8m/12 ET5.0% 8/y,	2
	BI-3&BI-4	1/2S d/2 4m/12 ET5.0% 1/y*	
VII (g)	HO-4+BI-3&BI-4	1/4S↑ + 1/2Sd/3 ET5.0% 12/y	2.5
	Total		32.5

*Tapping system during wintering period
Except in phase I, throughout the tapping schedule up to phase III, the use of stimulant is on staggered basis (1/2:1/2), phase IV onwards to all trees and on both cuts during the final phase VII.

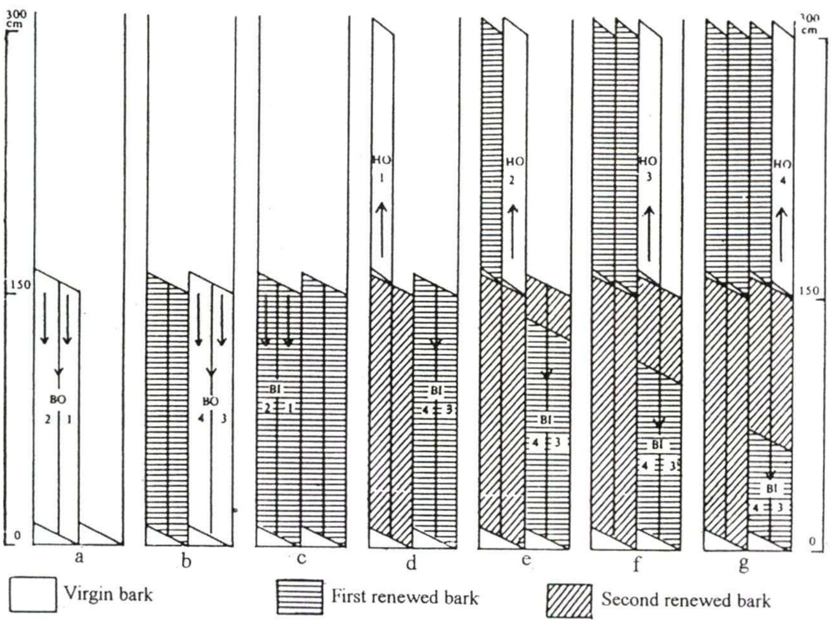


Figure 9.40 Succession of tapping panels for buddings (II)

TABLE 9.13 EXPLOITATION SYSTEM FOR BUDDINGS (III)

Phase *(Figure 9.41)*	Tapping panel	Daily tapping system but not exceeding twenty tappings per month	Period (year)
I (a)	BO-1	1/4S d/1 2d/3 ET2.5% 2/y	3
II (b)	BO-2	1/4S d/1 2d/3 ET2.5% 2/y	3
III (c)	BO-3	1/4S d/1 2d/3 ET3.3% 4/y	3
IV (d)	BO-4	1/4S d/1 2d/3 ET3.3% 4/y	3
V (e)	BI-1, BI-2	1/4S d/1 (t,t) 2d/3 8m/12 ET5.0% 6/y,	5
	BI-I&BI-2	2x1/4S d/1 2d/3 4m/12*	
VI (f)	HO-I	1/4S↑ d/1 2d/3 8m/12 ET5.0% 8/y,	1.5
	BI-3&BI-4	2x1/4S d/1 2d/3 4m/12*	
VII (g)	HO-2	1/4S↑ d/1 2d/3 8m/12 ET5.0% 8/y,	1.5
	BI-3&BI-4	2x1/4S d/1 2d/3 4m/12*	
VIII (h)	HO-3	1/4S↑ d/1 2d/3 8m/12 ET5.0% 8/y,	1.5
	BI-3&BI-4	2x1/4S d/1 2d/3 4m/12*	
IX (i)	HO-4+BO-3&BO-4	1/4S↑+2x1/4S d/2 ET5.0% 12/y	2
	Total		23.5

* Tapping system during wintering period
Except for phase I, throughout the tapping schedule up to phase V, the use of stimulant is on a staggered basis (1/2:1/2), phase VI onwards to all trees and on both cuts during the final phase IX

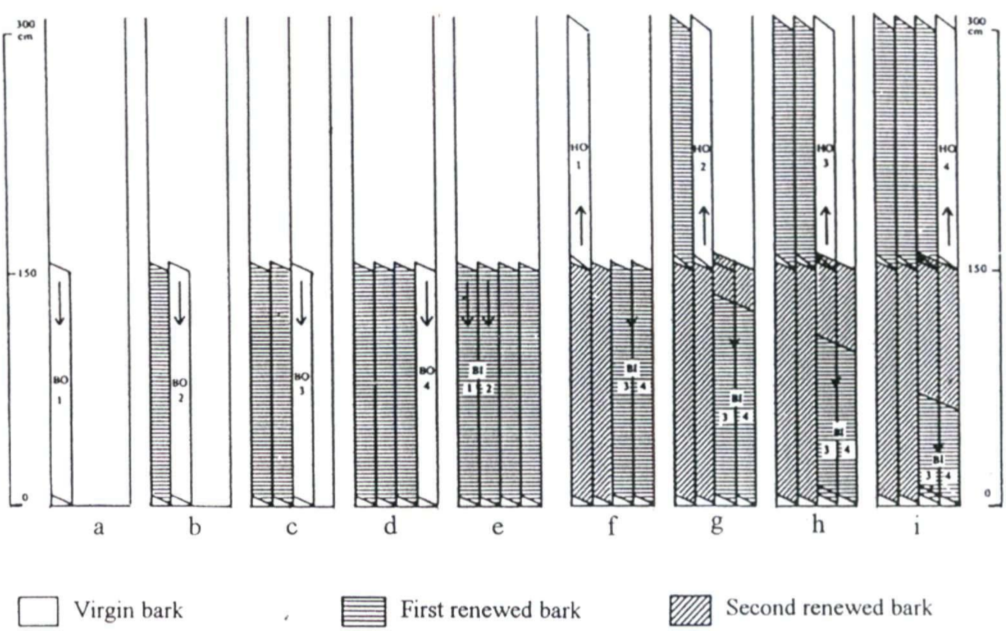


Figure 9.41 Succession of tapping panels for buddings (III)

TABLE 9.14 EXPLOITATION SYSTEM FOR BUDDINGS (IV)

Phase *(Figure 9.42)*	Tapping panel	Panel changing tapping system daily, but not exceeding twenty tappings per month	Period (year)
I (a)	BO-1, BO-2 BO-1&BO-2	1/4S d/1 (t,t) 2d/3 8m/12 ET2.5% 2/y, 1/2S d/1 2d/3 4m/12*	5
II (b)	BO-3, BO-4, BO-3&BO-4	1/4S d/1(t,t) 2d/3 8m/12 ET3.3% 3/y, 1/2S d/1 2d/3 4m/12*	5
III (c)	BI-1, BI-2, BI-1&BI-2	1/4S d/1(t,t) 2d/3 8m/12 ET5.0% 4/y, 1/2S d/1 2d/3 4m/12*	5
IV (d)	HO-1, BI-3&BI-4	1/4S↑ d/1 2d/3 8m/12 ET5.0% 8/y, 1/2S d/1 2d/3 4m/12*	1.5
V (e)	HO-2, BI-3&BI-4	1/4S↑ d/1 2d/3 8m/12 ET5.0% 8/y, 1/2S d/1 2d/3 4m/12*	1.5
VI (f)	HO-3, BI-3&BI-4	1/4S↑ d/1 2d/3 8m/12 ET5.0% 8/y, 1/2S d/1 2d/3 4m/12*	1.5
VII (g)	HO-4+BI-3&BI-4	1/4S↑+1/2S d/2 ET5.0% 12/y	2
	Total		21.5

* Tapping system during wintering period

Except for phase I, throughout the tapping schedule, the use of stimulant is on a staggered basis (1/2:1/2), phase VI onwards to all trees and on both cuts during the final phase VII

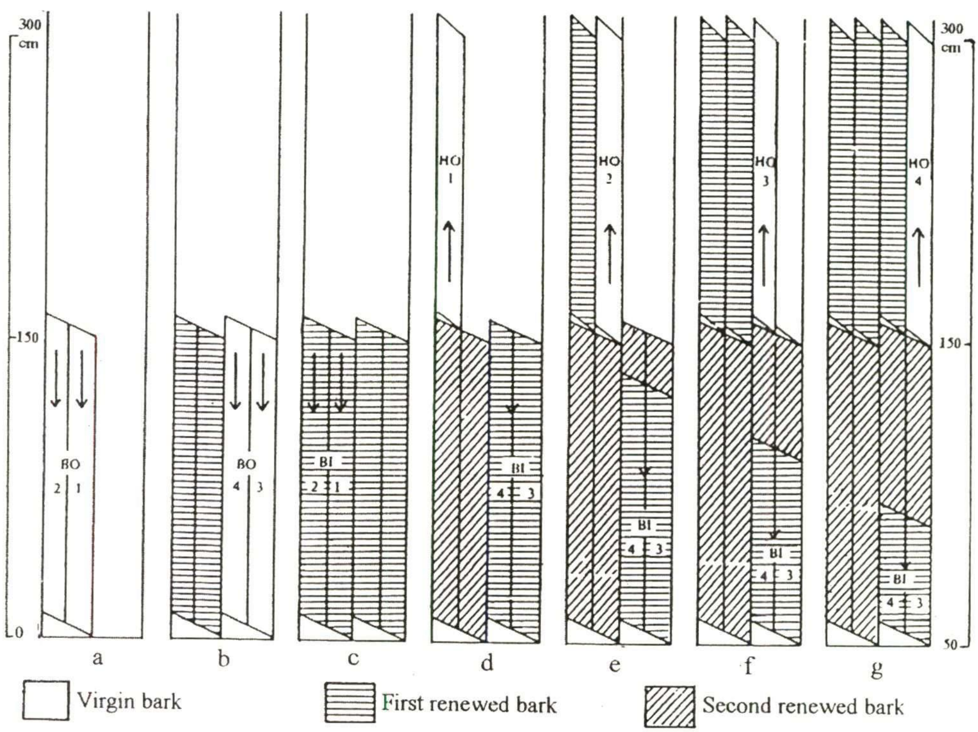


Figure 9.42 Succession of tapping panels for buddings (IV)

TABLE 9.15 EXPLOITATION SYSTEM FOR BUDDINGS (V)

Phase *(Figure 9.43)*	Tapping panel	Ultra-low frequency tapping system	Period (year)
I (a)	BO-1	1/2S d/6 ET1.5-2.0% 12/y	8-10
II (b)	BO-2	1/2S d/6 ET2.0-2.5% 12/y	8-10
III (c)	BI-1	1/2S d/6 ET5.0% 12/y	6-8
IV (d)	BI-2	1/2S d/6 ET5.0% 12/y	6-8
	Total		28-36

Ethepon stimulant application must be by the modified method of lace or groove plus 0.64 cm of scraped bark below the tapping cut

TABLE 9.16 EXPLOITATION SYSTEM FOR BUDDINGS (VI)

Phase *(Figure 9.43)*	Tapping panel	Periodic tapping system	Period (year)
I (a)	BO-1	1/2S d/3 9m/12 ET1.5-2.0% 9/y	7-8
II (b)	BO-2	1/2S d/3 9m/12 ET2.0-2.5% 9/y	7-8
III (c)	BI-1	1/2S d/3 9m/12 ET5.0% 9/y	6-7
IV (d)	BI-2	1/2S d/3 9m/12 ET5.0% 9/y	6-7
	Total		26-30

Ethepon stimulant application must be by the modified method of lace or groove plus 0.64 cm of scraped bark below the tapping cut

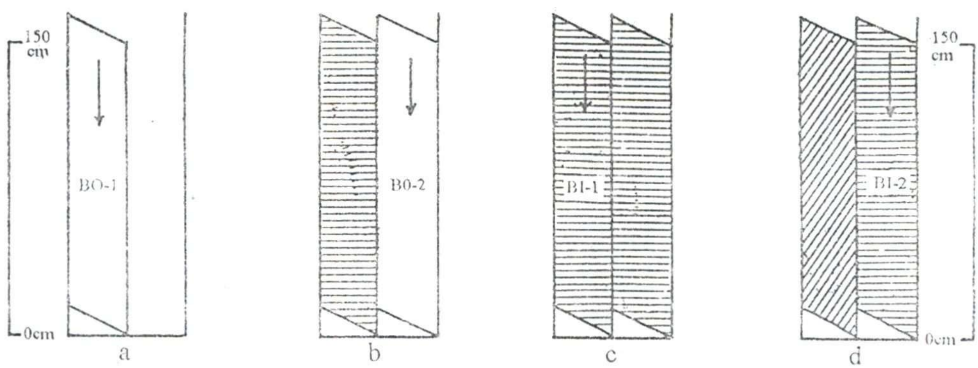


Figure 9.43 Succession of tapping panels for buddings V and VI

TABLE 9.17 EXPLOITATION SYSTEM FOR CLONAL SEEDLINGS

Phase *(Figure 9.44)*	Tapping panel	Tapping system	Period (year)
I (a)	BO-1	1/2S d/3 ET3.3% 2/y	4
II (b)	BO-2	1/2S d/3 ET3.3% 4/y,	6
III (c)	BO-3 & BI-1	1/2S d/3 ET5.0% 4-6y	6
IV (d)	HO-1,	1/2S↑ d/3 8m/12 ET5.0% 8/y	3
	BI-2	1/2S d/3 4m/12 ET5.0% 1/y*	
V (e)	HO-2,	1/2S↑ d/3 8m/12 ET5.0% 8/y,	3
	BI-2	1/2 d/3 4m/12 ET5.0% 1/y*	
	Total		22

*Tapping system during wintering period

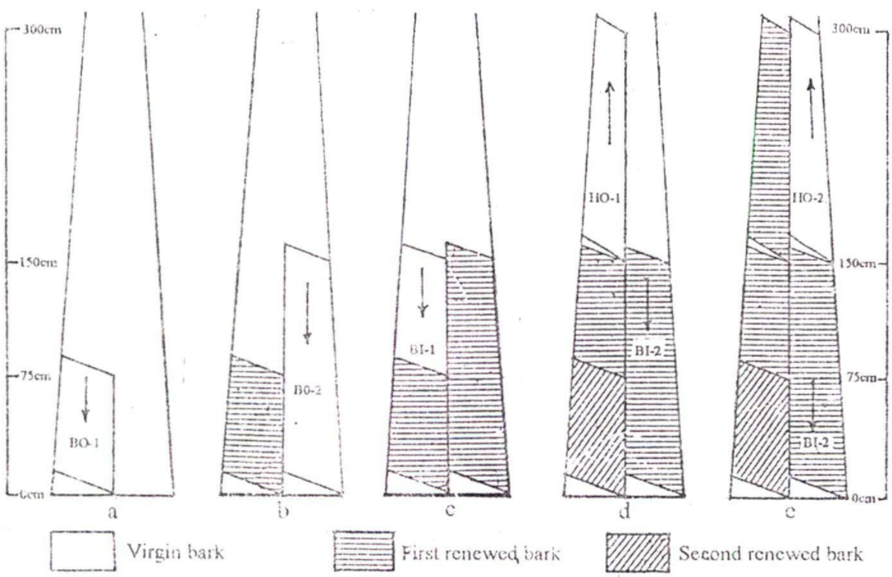


Figure 9.44 Succession of tapping panels for clonal seedings

It can be noted from the fifth and sixth exploitation schedules *(Tables 9.15 and 9.16)* that only the lower panels (BO and BI) are exploited. As such larger volumes of good quality timber can be recovered for downstream usage during replanting later on.

From experiments carried out, there was evidence showing that different clones respond differently with regards to tapping systems and stimulation. The above recommendations are therefore general in nature and can be modified accordingly depending on the situation.

If the trees have been stimulated from commencement of tapping, there may be marked drop in yield when the tapping cuts approach the base of the trees, unless the trees had been deeply planted during transplanting (deep planting technique). If this happens the panels should be changed immediately.

TAPPING MANAGEMENT

Besides the systematic development of the plantation, the usage of high quality planting materials and good plantation maintenance, the management and maintenance of the tapping operation are also important in determining the maximum yield return of the crop. The functions of the tapping management, therefore, can be considered as ensuring that the following are strictly implemented.

Attendance

The first thing that is required in a tapping operation is to ascertain whether tapping for the day can be carried out. If this is not possible, then recovery tapping must be arranged, either later in the day or tapping on a rest day. This is important to achieve maximum yield as well as to maintain the minimum number of tapping days in a month or year.

Attendance of tappers should be duly recorded and for those who are absent, replacement must be made to ensure that no tasks which have been scheduled to be tapped for the day are left untapped. It is also important to see that the tappers reach their tasks quickly and safely.

Tapping Equipment and Utensils

The supply of good equipment and utensils should also be ensured. This includes tapping knives, cups, spouts, buckets and others. They should be replaced immediately when found defective. The tapping knife is the most important item in effecting good tapping. Suitable ones should be supplied and must always be ensured that they are reasonably sharp.

Tapping Technique

Tapping should commence as early in the morning as possible. Scrap rubber such as the tree and spout laces and cuplumps are removed before tapping is done. The full length of the tapping cut within the panel boundary must be tapped away. The depth of tapping should be up to the maximum. However, contact with the cambium must be avoided. The thickness of tapping is kept to the minimum. It must be ensured that the latex actually flows into the cup. All tappable trees in the task are tapped.

Collection

Latex is only collected when it stops dripping, unless late dripping occurs. It is completely removed from the cup into the collecting bucket. Latex is collected from all trees tapped in the task for the day. Scrap rubber is also collected and placed in separate utensils.

Latex Stability and General Cleanliness

The stability of the latex must be maintained until it reaches the collecting station or factory. This means that the latex must be retained in its liquid condition. A high standard of cleanliness must be maintained to achieve this. This includes cleanliness of all equipment and utensils used and at the same time keeping the latex covered during transportation. Latex preservative must be used, if necessary. The latex cup should be placed in the inverted position when the tree is not tapped. All equipment returned to the store after tapping must first be cleaned.

Maintenance of Tapped Trees

All forms of injuries to the trees must be avoided. The slope of the tapping cut of either 20°, 30° or 45° must always be maintained. Its direction must always be at high left to low right. Steps to control bark consumption must also be carried out. The front and back vertical channels marking the panel boundary must be regularly serviced (deepened). If the trees are under stimulation programme, the application of stimulant must be properly carried out when due. The position of the latex cups and spouts must always be at suitable distance. The trunks of trees must be cleaned of mosses and scrap rubber from time to time. Trees reaching tappable size must be opened for tapping. Retasking must be implemented when the number of tapped trees in the task has either increased or decreased markedly. All defects and malfunction occurring to the trees or in the field that affect the tapping function must be duly reported.

Tappers' Welfare

It is also necessary to keep a complete record of the tappers' daily crops, especially if it is going to be used as the basis for payment of their wages. All tappers must be promptly and accurately paid for work done when due. Incentives must also be considered for those showing exemplary work. Tappers must be thoroughly trained; this includes in-service training when there are changes in the tapping systems or methods. No deviation of any form must be allowed to take place.

Task Census

The above information can be used in carrying out monitoring exercises when there is a drop in the yield of a plantation. Such an exercise is known as the task census. Each tree in the reported low yielding task is inspected and remarks are entered in the questionnaire. The results are then summarised and compared with the standard performance of a task. The information obtained may assist the management to improve the task concerned. This trouble-shooting exercise has in the past proved to be very useful to the management of plantations and substantial yield increases have been reported as a result of such census.

CHAPTER 10

NATURAL RUBBER PROCESSING

PROCESSING FIELD LATEX AND COAGULA

Processing of natural rubber itself covers quite a large part of rubber technology. This is because several processes can be made possible from the raw materials of the rubber tree, namely, latex and field coagula. Approximately 80% of the rubber tree yield is in the form of latex, while the other 20% is the lower grade field coagula, which includes cuplumps, tree laces and other forms of solid rubber. The field coagula are also known as scrap rubber. This chapter deals briefly with what can be done with the field latex and the field coagula.

Field Latex

Field latex, which is in liquid form, can be concentrated on coagulated. There are certain rubber products which require latex as their raw material. They are grouped under latex products, which consume some 20% of the world's rubber production. Thus, to facilitate transportation and storage, field latex which contains considerable amount of water must be concentrated, and this alone is a major process. However, most rubber products require solid rubber as their raw material. This necessitates the coagulation of field latex. Coagulation process is also necessary for the production of conventional sheet rubber, such as Unsmoked Sheet (USS), Ribbed Smoked Sheet (RSS), Air-dried Sheet (ADS) and crepes and the modern block Standard Malaysian Rubber (SMR). The powdered rubber process also comes under this category.

Field Coagula

Processing field coagula is simpler as the raw materials are already in solid form. It is mainly used for the production of lower grade crepe and block rubbers because of their higher dirt content compared to latex.

Superior Processing Rubbers

There are certain rubber products of fine quality which require rubber of special quality and properties. These come under the special or superior process which produces special rubbers, such as Deproteinised NR (DPNR), Epoxidised NR (ENR), Oil-Extended NR (OENR), Methyl-methacrylate Grafted Rubber (MGR) and Thermoplastic NR (TPNR).

A summary of the various processes of natural rubber is illustrated in *Figure 10.1* below:

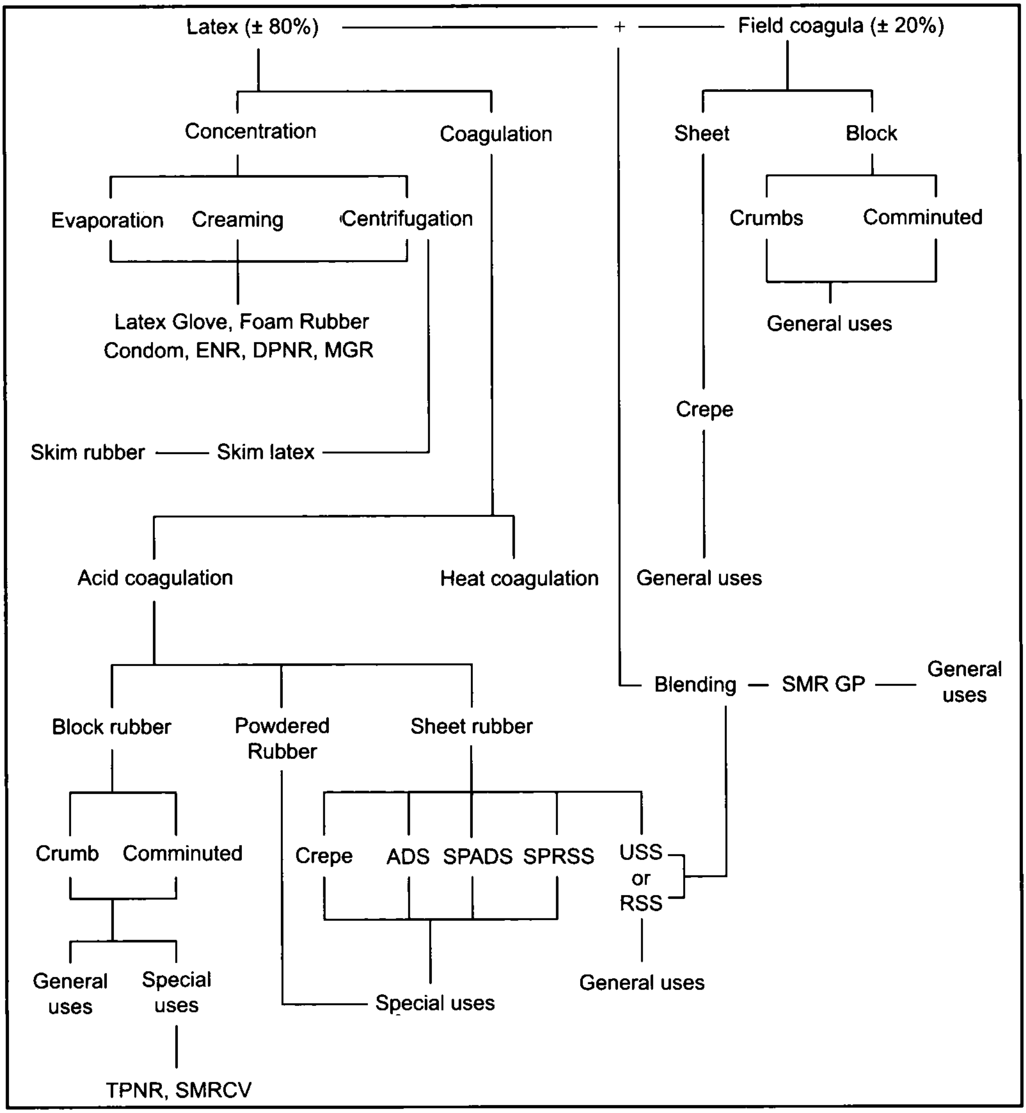


Figure 10.1 Natural rubber processing

CLEANLINESS IN PROCESSING

Cleanliness is an important factor in the processing of natural rubber, as it determines the quality of the rubber produced. The value of rubber depends very much on its quality, and a high quality rubber gives a high return of income to the planter, as the price paid by the consumer is according to its quality. Besides, good quality rubber has a much wider range of uses. At the consumers' end, it eliminates processing difficulties usually encountered with low quality rubber. Hence, high quality rubber is more readily marketable. There is also a premium in terms of price for good quality latex.

Everyone involved in the handling of latex, starting from the time it oozes out of the bark of the tree until it is finally processed, must be made to realise the importance of cleanliness. The latex that comes out of the bark of the rubber tree is clean naturally. It is contaminated and polluted by the people who handle it. Therefore, cleanliness should be practical in all three stages, namely, in the field, in the processing factory and during post-processing operation.

Field/Tapping Cleanliness

Cleanliness starts in the field. The most important thing to remember here is to maintain the liquid condition of the latex until it reaches the processing factory. This can be achieved by preventing precoagulation of the latex. Latex becomes precoagulated when it is contaminated with dirt. Therefore, it is necessary to ensure that only clean tapping equipment and collecting utensils, such as cups, spouts, buckets and churns are used. All scrap rubbers removed from the field must be collected in a separate container. Latex collected must not be exposed and must be brought to the collecting centre or factory immediately. Latex preservatives must be used to prevent precoagulation, if necessary.

Collecting centres must be kept clean and the work of weighing and transferring latex must be done with cleanliness in mind. There must be sufficient supply of clean water at the centre for necessary washings to be carried out.

Factory/Processing Cleanliness

General cleanliness must be maintained at the factory buildings and the surroundings. All equipment in the factory must be kept clean. There must be a sufficient supply of clean water for use at any time when the factory is in operation. The latex must first be strained to remove any dirt in it. A suitable strainer of twenty five mesh per centimetre made of monel-metal gauze should be used. The use of pure copper strainers should be avoided as this may contaminate the latex.

Post-processing Cleanliness

Rubber that has been processed must be washed clean and allowed to drip under shade in a clean place. Sheet rubber, such as USS, ADS and crepe must be hung individually for at least four hours before putting them in the drying chamber. Rubber must always be stored in a clean, dry and well-ventilated area. As for latex concentrate, it must be kept in covered drums or closed tanks.

PRESERVATION OF LATEX

Latex from all types of rubber trees naturally self-coagulates after it oozes out of the bark. The only difference is the time it takes to coagulate. This difference depends on the type of clone, the stability of the latex and the condition of the environment. Latex that is unstable not only creates difficulties in handling, but also in processing. Sometimes, latex is required to be kept for a longer period. Thus, preservation is necessary.

Single Preservative System

Chemicals can be used to delay the coagulation of latex. Some examples are sodium sulphite, ammonia and formalin. Sodium sulphite and formalin are not very effective in preserving latex for long periods, while ammonia at a higher concentration can preserve latex for a much longer period.

Sodium sulphite. Sodium sulphite is a white powder and marketed at 90-98% concentration. Before it is mixed with the latex, a stock solution of 3% is prepared by diluting 100 g sodium sulphite in 3 litres of water. For every 5 litres of latex, 75 ml of the stock solution is added. This chemical is only effective for a few hours. Excessive use of this chemical can cause defects in RSS and at the same time delays its drying. It is most suitable for latex that is to be processed into pale and sole crepes, but not block rubber. Sodium sulphite must be stored in airtight container in a cool place.

Ammonia. Ammonia is marketed as gas as well as clear liquid of 30% concentration. A stock solution of 1% is prepared by diluting 1 kg ammonia gas in 100 litres water or 160 ml ammonia liquid in 5 litres of water. For every 100 litres of latex, 100 ml of the stock solution is added. Ammonia liquid is very volatile; it must therefore, be kept in an airtight container. This also applies to ammonia gas which can escape easily. An unopened drum of ammonia liquid must first be placed inverted under water overnight, for use the next day. But the lid must be opened slowly to release the compressed air inside it. Concentrated ammonia is toxic to the skin. Therefore, parts of the body that come into contact with ammonia should be washed immediately. For safety, always use a face mask when handling ammonia.

Formalin. Formalin is available commercially in liquid form of 38-40% concentration. A 1% stock solution is prepared by diluting 50 ml of formalin in 2 litres of water. For every 5 litres of latex, 100 ml of the stock solution is added. Formalin is most suitable in preventing precoagulation of latex caused by bacterial activity in the field. But, it is not suitable for latex in the production of block rubber. Formalin which has been kept for a long time can slowly oxidise and become an acid. But it can be neutralised by adding calcium carbonate or sodium sulphite.

Composite Preservative System

Normally, field latex has to be transported over some distance to central processing factories due to the location of the plantation and therefore time is taken before delivery is made. This gives rise to the problem of volatile fatty acid (VFA) formation in latex and causes processing difficulties. Although ammonia at very high concentration can overcome this problem, it is rather costly. A composite preservative system is therefore introduced. It is more effective and cheaper compared to using ammonia alone.

HNS-Ammonia. This preservative system consists of two chemicals, hydroxylamine neutral sulphate and ammonia. It is most suitable for latex to be processed into block rubber of SMR CV and LV grades. *Table 10.1* gives the chemicals to be used while *Table 10.2,* the preparation of the stock solution.

TABLE 10.1 HNS-AMMONIA PRESERVATIVE SYSTEM

Preservatives of DRC weight (%)		Period of preservation (hours)	
HNS	**Ammonia**	**Estate latex**	**Smallholding latex**
0.15	0.03	11	5
0.15	0.05	11-19	5-11
0.15	0.07	19-30	11-20

Boric acid-Ammonia. This preservative system is also made up of two chemicals, boric acid and ammonia. It is most suitable for use on latex that is to be processed into block rubber of SMR L grade. The chemicals and the preparation of the stock solution are given in *Tables 10.3* and *10.4.*

TABLE 10.2 HNS-AMMONIA STOCK SOLUTION

DRC of latex (%)	A			B			C		
	NH3	HNS	SS	NH3	NHS	SS	NH3	HNS	SS
	(kg*)	(kg)*	(litre)	(kg*)	(kg)*	(litre)	(kg*)	(kg)*	(litre)
27	3.1	4.05	1.0	5.26	4.05	1.0	5.26	2.89	1.4
28	3.1	4.20	1.0	5.26	4.20	1.0	5.26	3.00	1.4
29	3.1	4.35	1.0	5.26	4.35	1.0	5.26	3.11	1.4
30	3.1	4.50	1.0	5.26	4.50	1.0	5.26	3.22	1.4
31	3.1	4.65	1.0	5.26	4.65	1.0	5.26	3.32	1.4
32	3.1	4.80	1.0	5.26	4.80	1.0	5.26	3.43	1.4
33	3.1	4.95	1.0	5.26	4.95	1.0	5.26	3.53	1.4
34	3.1	5.10	1.0	5.26	5.10	1.0	5.26	3.64	1.4
35	3.1	5.25	1.0	5.26	5.25	1.0	5.26	3.75	1.4
36	3.1	5.40	1.0	5.26	5.40	1.0	5.26	3.86	1.4
37	3.1	5.55	1.0	5.26	5.55	1.0	5.26	3.96	1.4

SS = stock solution; NH3 = ammonia; HNS = hydroxylamine neutral sulphate
* The weight of NH3 and HNS for 100-litre stock solution
# Volume of stock solution to be added per 100 litres of latex

TABLE 10.3 BORIC ACID-AMMONIA PRESERVATIVE SYSTEM

Preservatives of DRC weight (%)		Period of preservation (hours)	
Boric acid	Ammonia	Estate latex	Smallholding latex
0.2	0.03	16	11-15
0.3	0.07	32-60	29-40
0.5	0.03	34-44	20-27

TABLE 10.4 BORIC ACID-AMMONIA STOCK SOLUTION

System	For 100-litre stock solution		For 100 litres of latex
	Ammonia (kg)	Boric acid (kg)	Stock solution (litre)
A	1.5	10	2.0
B	3.5	15	2.0
C	1.2	20	2.5

TMTD-ZnO-Ammonia. This preservative system consists of three chemicals, 0.025% tetramethyl-thiuram disulphide (TMTD) and zinc oxide (ZnO) in the ratio of 1:1 and 0.4% ammonia *(Table 10.5).* The percentage of the chemicals is based on the weight of the latex. This preservative system is suitable for field latex which is intended for latex concentrate production. A 10% stock solution of ammonia is prepared and then mixed into the latex. This is followed by the TMTD-ZnO stock solution preparation by dispersion *(Table 10.6).* Mixing is done in a suitable plastic or stainless steel container (not aluminium) using an electric stirrer rotating at 500 rpm for ten minutes. For every 45.5 litres of the stock solution 45.5 litres of latex is added to form a masterbatch which can then be mixed with every 10,000 kg of latex that is to be preserved.

TABLE 10.5 TMTD- ZnO-AMMONIA PRESERVATIVE SYSTEM

Preservative (% on latex weight)				Period of preservation(day)
TMTD	ZnO	Lauric acid	Ammonia	2.0
0.013	0.013	0.05	0.2	

TABLE 10.6 TMTD-ZnO-AMMONIA STOCK SOLUTION

Material	Part by weight*
Water	75.000
Sodium hydroxide	0.013
TMTD	12.500
Dispersing agent (e.g. *Vultamol*)	0.025
ZnO	12.500

* The resultant solids content is 25%

In the preservation of field latex, it is of utmost importance to arrest the formation of VFA. Thus, preservatives must be added to the latex as early as possible. The rate of chemicals recommended earlier should serve as a guide. The user can make modification according to local conditions.

DRY RUBBER CONTENT IN LATEX

Latex can be considered as a biological product of complex structure. A large part of it is water. Other substances that make up latex are shown in *Table 10.7.*

Dry rubber content or DRC is referred only to the rubber particles found in latex. The DRC varies according to season, climate, soil condition, clone, age of trees, tapping system (length of cut and frequency of tapping), stimulation and other influences. Usually, the DRC of latex is within the range of 20-45% and 35% can be taken as an average.

TABLE 10.7 COMPOSITION OF LATEX

Content	Percentage
Total solids	20-48
Rubber particles	20-45
Proteinous substances	1.5
Resinous substances	2.0
Carbohydrates	1.0
Inorganic materials	0.5

Objectives of DRC Determination

There are several reasons for determining DRC in latex. It is mainly used as a guide in:

- Latex trading
- Standardisation of latex for RSS and Block Rubber production
- Payment of tappers' wages
- Management of latex factories
- Calculation of chemicals required for the processing of latex
- Finding out the yield of an area

Methods of DRC Determination

There are no less than eight methods to determine the DRC of latex, from the least to the most accurate. However, in this book, only three are discussed, namely the standard laboratory method, the dipper method (previously known as the Chee method) and the hydrometer metrolac method. Brief descriptions of these are given below:

Standard laboratory method. Strain the latex the DRC of which is to be determined. Weigh the latex in kilogrammes. Stir the latex, and take about 45 ml of the latex into a conical flask. Weigh out 20 g of the latex into a clean dish for use as sample. Add slowly 150 ml of 0.5% acetic acid into the dish, at the same time rotating it gently. Place the dish over a steam bath until the latex sample coagulates with a clear serum formed over it. Remove the coagulum and press roll into a thin biscuit of 2 mm thickness. Dry the biscuit in an oven at 70 °C for sixteen hours. Cool the biscuit in a dessicator for a few minutes. Weigh the biscuit in grammes. Carry out the determination in duplicate. Duplicate results must check to within 0.2%. The formula for the calculation of the DRC is as follows:

$$\text{DRC} = \frac{\text{Weight of biscuit}}{\text{Weight of latex sample}} \times 100 = \text{DRC percentage in latex}$$

$$\frac{\text{Weight of biscuit} \times \text{Weight of whole latex}}{100} = \text{DRC weight of whole latex}$$

Example :

	First sample	Second sample
Weight of flask + latex	65.632 g	44.873 g
Weight of flask	44.873 g	23.410 g
Weight of latex	20.759 g	21.463 g
Weight of biscuit	6.572 g	6.768 g
DRC percentage of latex	$= \frac{6.572}{20.759} \times 100$	$\frac{6.768}{21.463} \times 100$
	= 31.659%	31.533%

Average DRC of latex = (31.659 + 31.533) / 2
= 31.60%

Assume that weight of whole latex = 50 kg

DRC weight of whole latex $= \frac{31.60 \times 50}{100}$

= 15.80 kg

This is the most accurate method of determining the DRC of latex with a total error of only 0.048. But it a slow method and requires high capital cost and trained personnel to perform the test *(Figure 10.2)*.

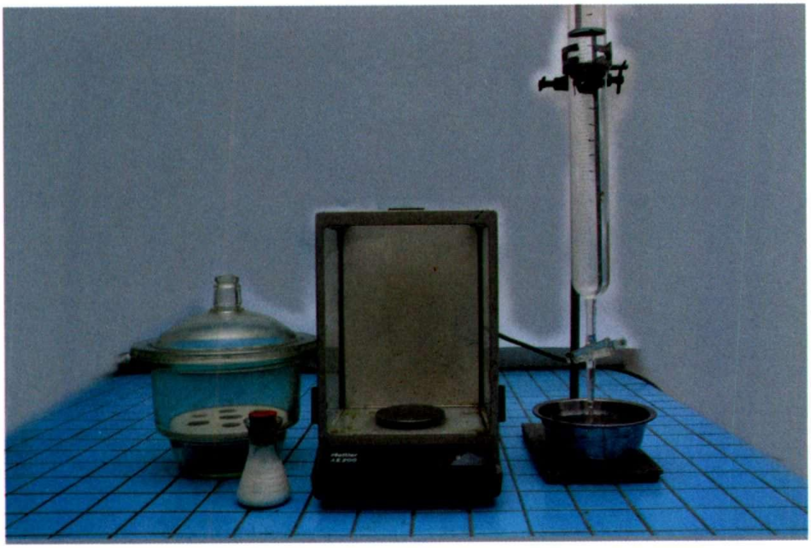


Figure 10.2 Apparatus for the determination of DRC of latex by the laboratory method

The Dipper (Chee) method. Strain the latex, the DRC of which is to be determined. Weigh the latex in kilogrammes. Stir the latex well, and using a special dipper take away 50 ml of the latex into a clean dish for use as sample. Rinse the dipper with some clean water and add the washing to the latex sample. Coagulate the latex sample with 25 ml of 1% formic acid. When a clear serum is formed, remove the coagulum and wash it carefully. Press roll the coagulum into a thin biscuit of 2 mm thickness. Dry the biscuit in an oven at 70 °C for sixteen hours. Weigh the biscuit in grammes. The formula for calculating the DRC is as follows:

$$\frac{\text{Weight of biscuit}}{\text{Weight of latex sample}} \times 100 = \text{DRC percentage in latex}$$

$$\frac{\text{Weight of biscuit} \times \text{weight of whole latex}}{100} = \text{DRC weight of whole latex}$$

Example :

Weight of whole latex	=	35 kg
Weight of latex sample	=	50 g
Weight of biscuit	=	15 g

DRC percentage of latex = $\frac{15 \times 100}{50} = 30\%$

DRC weight of whole latex = $\frac{30 \times 35}{100} = 10.5$ kg

This method is less accurate with a total error of 0.306. The capital cost is lower, but it is still a slow method *(Figure 10.3)*.

Figure 10.3 Apparatus for the determination of DRC of latex by the dipper or "chee" method

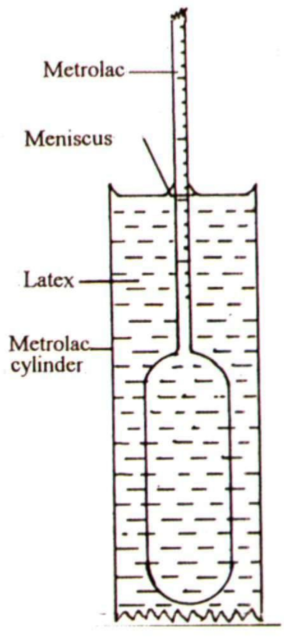


Figure 10.4 Apparatus for the determination of DRC of latex by the hydrometer metrolac method

Hydrometer method. Strain the latex, the DRC of which is to be determined. Measure the latex in litres or weigh it in kilogrammes and then convert it to litres, based on 1 kg per litre. Stir the latex well. Using a long-handled dipper, and dipping it right down the latex, take away one measure of latex and pour it into a suitable container. Add two measures of clean water and mix them thoroughly by pouring from one measure into another several times. Transfer the latex into a cylinder until it overflows. Remove the froth formed on the surface of the latex by blowing it off. Dip the hydrometer metrolac slowly inside the latex and allow it to rest. Note the reading on the metrolac stem at the meniscus. Confirm this reading by slightly pushing in the metrolac in the latex and allowing it to rest again *(Figure 10.4)*. The formula for calculating the DRC is as follows:

$$\text{Metrolac reading} \times 3 \times \text{volume of whole latex} = \text{DRC weight of whole latex}$$

$$\frac{\text{DRC weight of whole latex}}{\text{Weight of whole latex}} \times 100 = \text{DRC percentage in latex}$$

Example:

Volume of whole latex	=	100 litres		
Dilution	=	1:2	=	3 parts
Metrolac reading	=	105		
DRC weight of whole latex	=	105 x 3 x 100		
	=	31, 500 g		
	=	31.5 kg		
DRC percentage of latex	=	$\frac{31.5 \times 100}{100}$	=	31.5%

This method is very fast and the capital cost is very low. But it is less accurate with a total error of 4.053. This method is not recommended for latex trading purposes. The metrolac reading too can be influenced in several ways. There were cases of latex being adulterated to enhance the metrolac readings. *Table 10.8* gives a summary of the effect of adulterants and external treatments of field latex determined by its metrolac method.

Choice of Method

The choice of method to determine the DRC of latex depends on the conditions and the facilities available at a particular location or situation and for the purpose it is intended. However, in the course of latex trading, in which fairness is very important, the most accurate method must be used.

TABLE 10.8 EFFECT OF SOME ADULTERANTS AND EXTERNAL TREATMENTS OF FIELD LATEX ON METROLAC DRC

Adulterant	Effect
Wheat flour	Significant depression of DRC
Soap powder	
Tapioca starch	
Common salt	
Sodium sulphite	
Lime	
Formalin	Very slight depression of DRC
Fern juice	
Coconut water	
Pineapple leaf juice	
Alum	
Cup lump serum	
Pineapple juice	
Coconut milk	No effect
Rambutan leaf extract	
Calcium carbide	
Formic acid	
Aeration	
Ammonia solution	Very slight elevation of DRC
Boiling water	
Heat	

MICROWAVE RAPID METHOD FOR DETERMINING DRY RUBBER CONTENT OF CUPLUMPS

The microwave rapid method for determination of DRC of cuplumps is developed to enable a quantitative analysis of DRC in the fields and at rubber processing factories. The method is simple, low cost and easy to operate which will provide reliable estimation of cuplump DRC to complement the existing standard method that can only be conducted in the laboratory. The development of microwave rapid method will make raw rubber trading particularly at the farm gate level more transparent and less susceptible to DRC manipulations particular during recent trend of high rubber price. The method has been optimised by considering main factors influencing the determination of DRC including sample size, contamination by foreign materials, age and form of cuplumps. Laboratory and field trials of the method showed that the accuracy of DRC determination could be achieved within ± 2% accuracy compared to the standard laboratory method. The method has also been extended for DRC determination of creped cuplumps for factory applications which yielded high accuracy within a test period of less than 1 hour.

Presently, the determination of DRC of cuplumps is mainly done qualitatively through visual observations by rubber dealers. The rubber content of a cuplump is measured based on DRC which varies from 45% to 75% depending on its age and dryness. This method is adopted since the standard method for determining DRC is only suitable to be conducted in the laboratory. The standard method requires a significant equipment investment and an average period of 2 to 3 days to be completed. The procedure for DRC determination in the laboratory based on the standard method begins with a cleaning stage of cuplumps using a creper equipped with a high pressure water spray. Cuplumps are simultaneously processed into a thin rubber sheet to facilitate drying process of the rubber in an oven. The DRC of cuplump is obtained by calculating the percentage of dry weight over the initial wet weight of the cuplump.

Development of a rapid method for DRC determination of cuplump is to improve and to address problems of DRC determination. In principle, the rapid method incorporates a rapid rubber drying technique based on microwave technology. The rapid method is simple, low cost, fast, and can be readily conducted outside laboratory (*Figure 10.5*).

Figure 10.5 Field trial using the rapid method at a rubber dealer premise

The procedure begins by cutting a cuplump into four equal portions and subsequently drying the samples using a suitable microwave oven for a specified time period (*Figures 10.6-10.9*). The drying period depends on size and weight of the cuplump samples. For example, microwave oven with a power output of 600 W is capable of drying 1000 g of rubber uniformly in less than 60 minutes.

Figure 10.6 Cuplump with minimal contamination

Figure 10.7 Cuplump samples before drying

Figure 10.8 Cuplump samples after drying with appropriate setting

Figure 10.9 Uniformly dried cuplump samples to confirm complete drying

Microwave Rapid Method for Creped Cuplumps

The microwave rapid method was further developed for creped cuplumps as a means to improve the current method for DRC determination of cuplumps at rubber factories. A common method to determine DRC of cuplumps by rubber processors is to obtain 30 kg of random (grab) samples from every shipment of cuplumps. The samples are then cleaned and processed in creped form and dried in commercial dryer to enable determination of DRC. This method requires a period of 5 to 8 hours for completion. The microwave rapid method was extended to creped rubber by replacing the drying of samples in a commercial dryer with microwave drying; thus allowing the period of the DRC determination to be reduced to less than 1 hour. As creped rubber represents a homogeneous form of cuplumps, a sample creped cuplumps of with a minimum weight of 400 g was obtained to represent the cuplump samples to be dried using microwave *(Figure 10.10)*

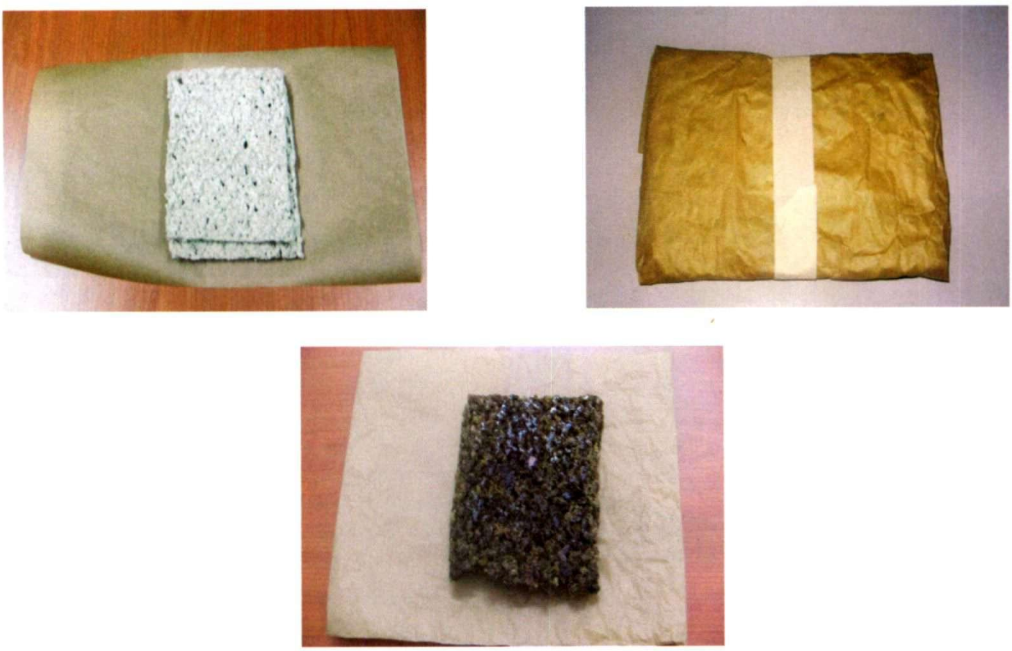


Figure 10.10 Preparation of creped cuplumps for microwave rapid method and creped cuplumps after drying

The microwave rapid method rapid was able to provide a very accurate determination of DRC in comparison of the DRC obtained using the common dryer method. Also, the microwave rapid method could be used effectively for creped cuplumps as an improvement of the current method used at rubber factories.

National Guideline on Determination of Dry Rubber Content of Cuplumps

Trading of cuplumps between rubber dealers and smallholders normally occurred in remote places around the country involving small quantities of cuplumps which weigh less than 50 kg per transaction. The price of the cuplumps is determined purely based on its dry rubber content (DRC) commonly through visual observation by rubber dealers and factories. This practice of determining DRC through visual observation combined with other price cut mechanisms imposed by rubber buyers has led to dissatisfaction among smallholders during rubber trading *(Figure 10.11a and Figure 10.11b)*. Since there is no standard method available in the industry for farmgate determination of cup lump DRC, it has indirectly discouraged smallholders from producing good quality cuplumps as a consequence of their dissatisfaction during rubber trading.

Figure 10.11(a) DRC determination through visual observation

Figure 10.11(b) DRC determination through price cut mechanisms

The guideline was developed with the main objectives to disseminate information on DRC of cuplumps produced by smallholders in Peninsular Malaysia and to stress the importance of producing high quality cuplumps to achieve high DRC values. The guideline provides an average DRC as functions of storage period and physical characteristics of the cuplumps. This guideline is suitable to be used as a guideline in the trading activities of cuplumps involving rubber dealers and smallholders to improve transparency of rubber transactions. The target groups for the usage of this guideline are smallholders, rubber dealers and also the rubber processing factories *(Figure10.12)*.

Figure 10.12 Usage of guideline in rubber plantation

The sampling was carried out throughout Peninsular Malaysia and covered all three seasonal variations in rubber growth period (*Figure 10.13*).The factors that influencing the dry rubber content determination were the drying period, size of the cuplump that been produced, impurities in cuplumps, multi layered cuplumps from a few tapping session, coagulum from rain contaminated latex and storing area under shade/without shade *(Figure 10.14 and Figure 10.15).*

Figure 10.13 Sampling areas for national guideline on determination of dry rubber content of cuplumps throughout Peninsular Malaysia.

Day 0

Day 3

Day 8

Day 12

Figure 10.14 Examples of good quality cuplumps

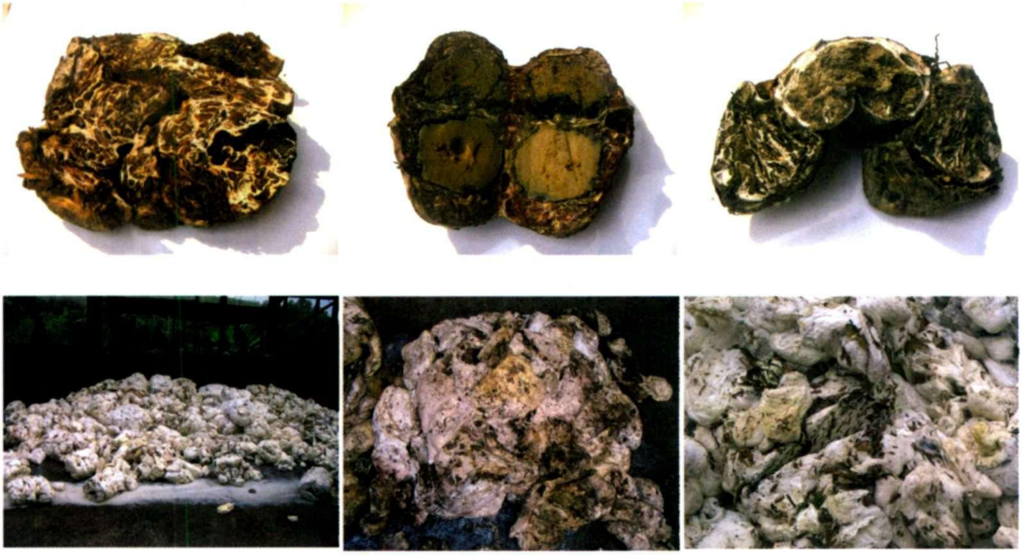


Figure 10.15 Examples of low quality cuplumps

All in all, this guideline will increase revenue and socio economic status of smallholders as main rubber producer and improve rubber transaction and transparency of DRC determination based on accurate scientific method. In addition, the guideline will encourage production of quality raw material to ensure Malaysian rubber industry remains productive, superior and competitive.

PRODUCTION OF USS

USS is one of the many forms of rubber processed from latex. Considered a conventional process, some 6.2% of Malaysia rubber is presented in this form. Most of the USS produced come from the smallholdings sector, where the latex is processed in small quantities individually or in groups at government sponsored processing centres. On the other hand, bulk production of USS is carried out in large plantations or estates and other centralised processing agencies, in which large volumes of latex are dealt with. Whatever it is, the most important thing to remember in USS production is cleanliness, from the field right up to the end of the production line.

Bulk USS Production

Stages in bulk USS production normally carried out in a central processing factory are described below:

Bulking and standardisation. First of all, make sure that the factory building and all its equipment are in clean condition. There must be sufficient amount of clean water available at all times. When field latex arrives at the factory, it is transferred into the bulking tank to obtain uniformity of the latex as well as the finished product. The DRC of the latex is estimated for standardisation purpose. Latex is normally standardised to 12.5, 15 or 20% DRC, depending on the practice of each factory. This is achieved by diluting the field latex with sufficient volume of clean water, which can be calculated according to the following formula:

$$\text{Volume of water required} = \frac{\text{Volume of field latex x DRC\%}}{\text{DRC \% to be standardised}} - \text{Volume of field latex}$$

Example:

Volume of field latex	=	2, 000 litres
Its DRC	=	35%
DRC to be standardized	=	15%

$$= \frac{2{,}000 \times 35}{15} - 2{,}000 \quad = \quad 2{,}667 \text{ litres}$$

After the addition of correct volume of water, a few minutes rest is allowed for the impurities to settle.

Coagulation and sheeting (milling). The standardised latex is then transferred into the coagulating tank. The latex is made to pass through sixteen to twenty four mesh per centimetre monel-metal gauze strainer to separate dirt and any other foreign particles that may be present in it. The coagulating tank comes in various sizes, accommodating between 900 and 1,000 litres of latex *(Table 10.9).* The number of tanks required in a factory depends on the volume of latex to be processed.

Latex is coagulated by formic acid at pH 4.5-4.8. *Table 10.10* gives the approximate quantity of acid and water to be added to coagulate 500 litres of diluted latex. The exact amount can be calculated by titration and confirmed by the pH paper. The latex should be well stirred, and all froth removed. The required amount of diluted acid is poured into the coagulation tank and thoroughly stirred with the latex. The partition sheets are then placed in position and the tanks covered.

TABLE 10.9 DILUTION OF FORMIC ACID

Acid-water	12.5% DRC	15% DRC	20% DRC
Acid	220 ml	250 ml	344 ml
Water	20 litres	23 litres	30 litres

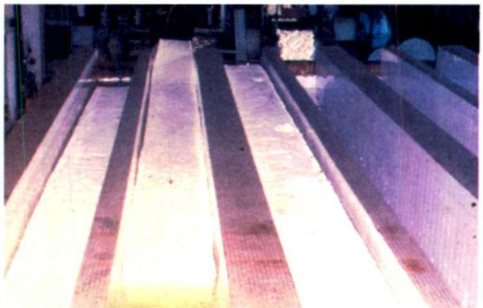
The latex is considered coagulated when a clear serum is seen over the coagulum. The tank is then flooded with clean water to submerge the coagulum, thus preventing oxidation. Milling (sheeting) is normally carried out the following day, when the coagula are firm enough for easy handling. The partition sheets are removed, and the coagulum slabs taken out and allowed to pass through three to four pairs of motorised smooth-surfaced roller presses, popularly known as the sheeting battery, to reduce the thickness to 4 mm. The sheets are then passed through a pair of groove-surfaced roller presses to give the sheets the ribbed appearance as well as to quickly drain off surface water. During milling, ensure that sufficient running water is dripped over the sheets. At the end of the milling line, the sheets are again washed. The long sheets are then cut into shorter lengths before being hung individually on a trolley and allowed to drip in a clean shady area for four hours prior to drying them in the smokehouse *(Figure 10.16)*.

TABLE 10.10 DCL-ALL-ALUMINIUM LATEX COAGULATING TANKS

Separate sheet tank with smooth sides				Continuous sheet tank with V-shaped sides			
Approximate inside dimension in cm or (inch)	**Number of partition**	**Maximum working depth in cm or (inch)**	**Total working capacity in litre or (gallon)**	**Approximate inside dimensions cm or (inch)**	**Number of partition**	**Maximum working depth in cm or (inch)**	**Total working capacity in litre or (gallon)**
304.80 X 91.44 X 40.64	75	34.3	918	304.80 X 91.44 X 40.64	75	37.5	968
(10' X 3' X 16")		(13.5")	(202)	(10' X 3' X 16")		(14.75")	(213)
304.80 X 91.44 X 40.64	90	34.3	909	304.80 X 91.44 X 40.46	90	37.5	968
(10' X 3' X 16")		(13.5")	(200)	(10' X 3' X 16")		(14.75")	(213)
304.80 X 91.44 X 45.72	75	39.4	1,054	304.80 X 91.44 X 45.72	75	42.5	1,100
(10' X 3' X 18")		(15.5")	(232)	(10' X 3' X 18")		(16.75")	(242)
304.80 X 91.44 X 45.72	90	39.4	1,045	304.80 X 91.44 X 45.72	90	42.5	1,100
(10' X 3' X 18")		(15.5")	(230)	(10' X 3' X 18")		(16.75")	(242)

Source: DCL = Diethelm Malaysia Sdn. Bhd (Engineering Division)

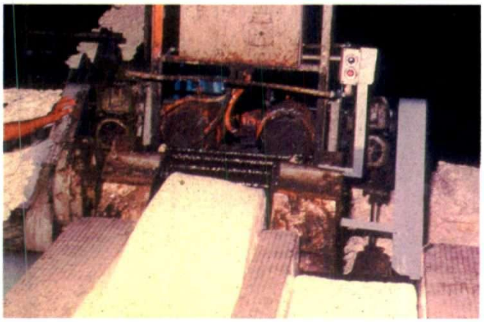
(a) Bulking and diluting latex



(b) Transferring into coagulating tank

(c) Adding formic acid and stirring

(d) Partitioning



(e) Removing coagulum and milling

(f) Cutting long sheet to required length

(g) Drying

Figure 10.16 Bulk processing of USS

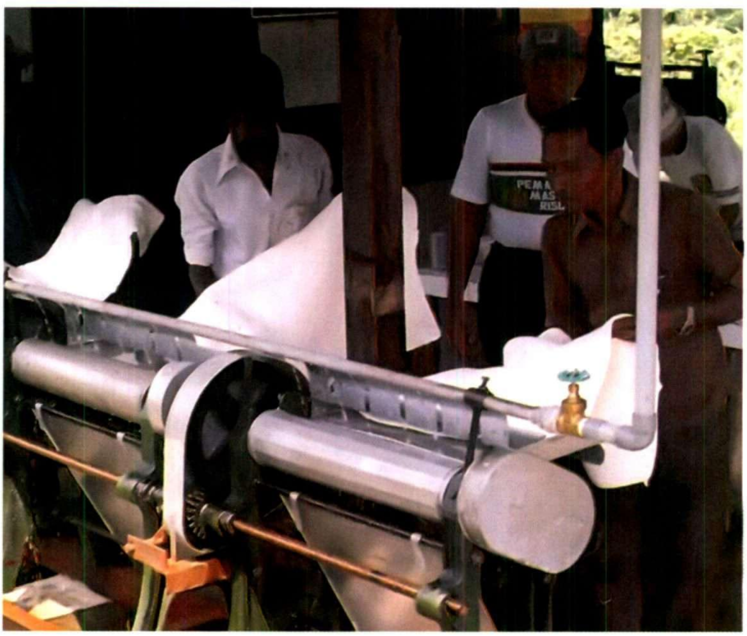
USS Production from Smallholdings

More than 70% of the Malaysian rubber production comes from smallholders. Some of them sell their latex to MARDEC and other commercial factories to be processed in bulk, either as USS, block or concentrates. However, a small number of them still process their latex into USS individually. There are two methods of processing smallholders' latex into USS – the coagulating pan and the mini coagulating tank. Procedures of both techniques are described below.

Coagulating pan method. As usual, the processing area and all its equipment must be in clean condition, with adequate supply of clean water available. The field latex is first diluted with equal volume of clean water. The diluted latex is passed through a pair of sixteen mesh per centimetre monel-metal gauze strainers into another bucket. The latex is then transferred into the coagulating pan at 5 litres each. Formic acid is diluted at 2.5%, that is, 15 ml (equivalent to one table spoonful) in 560 ml (or two milk tins equivalent) of clean water. The latex is stirred and all the froth formed over its surface removed. Diluted acid at 280 ml (equivalent to one milk tin) is poured into each pan and thoroughly stirred. The pan is then covered. Coagulation takes place in about half an hour. When a clear serum is seen in the pan, clean water is poured in to flood the coagulum. Once the coagulum is firm enough to handle, it is removed from the pan on to a table and pressed to a thickness of about 2 cm using the palm of the hand or a clean iron pipe. The coagulum is then passed through a pair of smooth-surfaced rollers three to four times to reduce the thickness to about 4 millimetres. After that, the rubber sheet is passed through a pair of groove-surfaced rollers once. They are then washed and hung individually to drip before drying them in the smokehouse *(Figure 10.17).*

Mini coagulating tank method. As usual cleanliness is to be emphasised. The field latex is first diluted with equal volume of water. The diluted latex is then transferred into the mini coagulating tank (40-litre capacity) through a pair of sixteen mesh per centimetre monel-metal gauze strainers. Formic acid is diluted to 2.5%, 60 ml in 2.25 litres of clean water. The latex is stirred and the froth formed over its surface is removed. The diluted acid is poured into the latex and thoroughly stirred. The partition plates are then placed in position and the tank is covered. Coagulation usually occurs in about half an hour. When a clear serum is seen, the coagulum is flooded with clean water. Once the coagulum is firm enough for handling, the first partition plate is removed.

(a) Gentle stiring to mix acid and latex in pans for coagulation



(b) Milling of coagulum through smooth roller on the left and groove roller on the right

(c) Dripping and drying of rubber sheets

Figure 10.17 Processing of USS by pan coagulation method

This is followed by removing the first coagulum slab. Then, the second plate is removed, followed by the coagulum slab. This procedure is continued until all the eight coagulum slabs are taken out. The coagulum slabs are passed through a pair of smooth-surfaced rollers three to four times until the thickness is reduced to 4 mm. The sheets are then passed through a pair of groove-surfaced rollers once. They are washed and hung to drip as previously described *(Figure 10.18)*.

The mini coagulating tank is an improvement over the conventional coagulating pan method. It is specially designed for use by smallholders, whose average crop per tapping is about 20 litres. It is made of thick aluminium sheet with a size of 43.2 cm x 31.75 cm x 30.48 cm and a capacity of 40 litres. It offers several advantages over the conventional coagulating pan in terms of durability, portability, space, equipment used, time saved, and more important of all, quality control.

SMOKEHOUSE AND THE DRYING OF USS

The production of USS is incomplete until the sheets produced go through the drying process. USS is dried in a smokehouse. A smokehouse can be permanent or semi-permanent. The permanent smokehouse is made of bricks, while the semi-permanent is made of plank or aluminium sheet wall with wooden structure. In the past, smallholders used to build small size temporary smokehouses, using easily available jungle rollers for the structures, with mud or bamboo stems as walls. But these are not seen anymore these days.

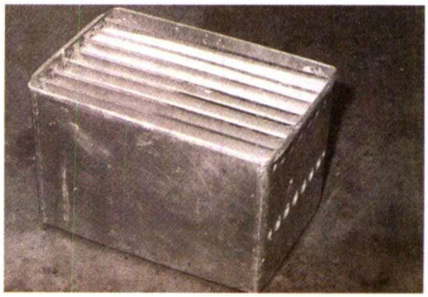
(a) Diluting latex

(b) Straining latex

(c) Coagulating

(d) Stirring

(e) Removing froth



(f) Placing partition plates

(g) Removing coagulum from tank

(h) Preparing coagulum for roller

Figure 10.18 Individual processing of USS by mini coagulating tank

Since the early thirties, the RRIM (now MRB) had developed a number of designs for smokehouses, and in 1964 a new improved series was introduced. They have designed RRIM Type 1100, 2200, 3300, and 4400 with capacities of 500, 1,000, 1,500 and 2,000 kg, respectively.

Site and Construction

As the furnace is constructed below ground level, the smokehouse is located on higher ground to prevent water seepage. To facilitate transportation, it should preferably be built as near to the processing centre as possible. However, is should be sited at least 15 m away from dwelling houses to reduce fire hazard.

A smokehouse is almost like any other building, but minus the rooms and other amenities found in a normal dwelling. It is, therefore, an empty chamber, but with doors and windows known as ventilators. The ventilators are sited on the roof or on the upper part of the smokehouse wall, with their openings and shuttings that can be controlled from the ground level. The furnace is constructed underground and outside the smokehouse. The hot smoke is passed into the smokehouse chamber through a tunnel with several outlets along the central length of the floor. The furnace also has a door and baffle to facilitate the control of temperature. It is made of fire-bricks laid in an arch formation at the upper part *(Figure 10.19a).*

In 1983, the RRIM (now MRB) designed another smokehouse (Drawing No PT 480). It has a capacity of 120 kg, and is most suitable for use by groups of three to five smallholders. The construction is of new concept using two layers of aluminium sheet walls for quick heat build-up in the smokehouse chamber. The furnace is made of metal cylinder, very much smaller in size than the normal one and located above ground level, in the smokehouse chamber itself. Such furnace is expected to provide direct heat into the chamber, and at the same time reduces fuel consumption *(Figure 10.19b).*

In 1986, the RRIM (now MRB) introduced a smokehouse that uses solar energy during the day and firewood fuel during the night thus saving fuel cost. But such a smokehouse required solar panel and in high capital cost *(Figure 10.19c).* The structural plans of all the RRIM Type Smokehouses are available from MRB on request.

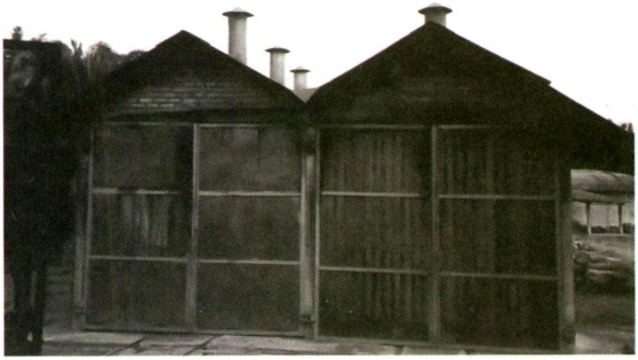
Objectives of Smoking USS

USS can be dried by atmospheric air, but the process takes more than three weeks. As they have to be hung individually, they take a lot of space and cause a lot of other inconveniences, too. Furthermore, they get infected by mould (fungus) which brings down their quality. With the smokehouse, the drying time can be reduced by about 80% and at the same time mould growths can be prevented. USS dried in this way become translucent against light and this facilitates its grading.

Operation of Smokehouse

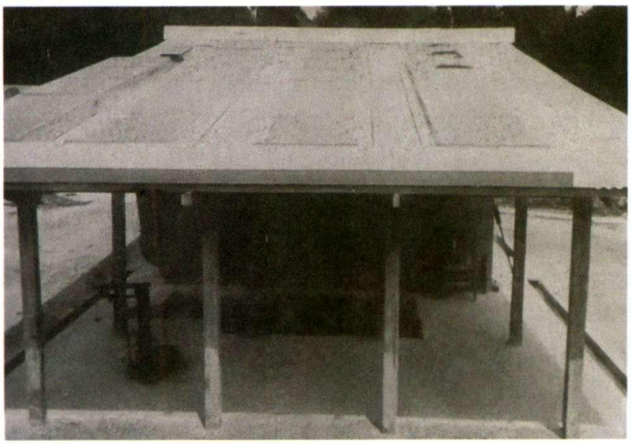
Freshly produced sheets that are to be placed in the smokehouse must first be dripped off the surface water. This is done by hanging the sheets individually on horizontal poles under shade, in a clean area for at least four hours. If they have been kept outside for a long period, it is likely that they have mould growing over them. Therefore, they should first be washed to remove the mould, hung to drip and later put in the smokehouse as previously described. In the smokehouse, the sheets are also hung individually on horizontal poles in tiers, the number depending on the size and capacity of the smokehouse. Rubber wood of 50-100% dry is usually used as fuel. It is cut to the required length of 75 cm with minimum diameter size of 15 cm. For the first round of firing, three logs are burnt, with one log added at intervals of four hours to obtain a constant temperature. The fuel should never be allowed to produce flame, as this will not only produce excessive heat and damage the rubber, but also consume a lot of fuel. What is needed is a constant supply of hot smoke. The temperature range required in the smokehouse is 50-65 °C, which can be determined by the use of a thermometer. The correct temperature can be obtained by using suitable fuel, topping it up at four hourly intervals and proper use of the ventilators. The rubber sheets will be dried in about 100 hours *(Figure 10.20)*. It is estimated that 1 kg of firewood is required to dry 1 kg or rubber.

Rubber sheets can also be dried by other methods, such as heat from the burning of oil and electricity. However, at the final stage, the rubber must go through the smoking process to conform with the production requirement of RSS.



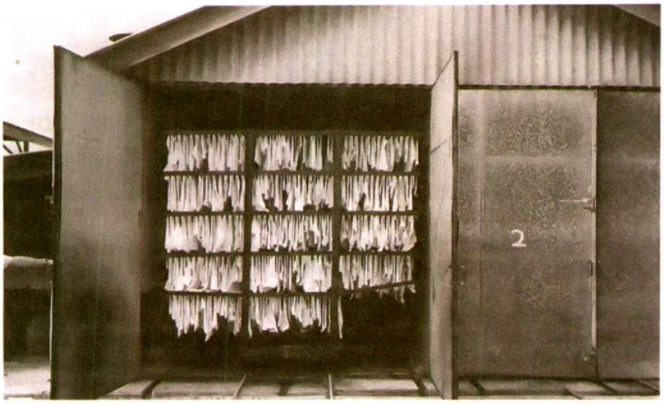
(a) RRIM Type smokehouse

(b) RRIM aluminium-walled smoke cabinet

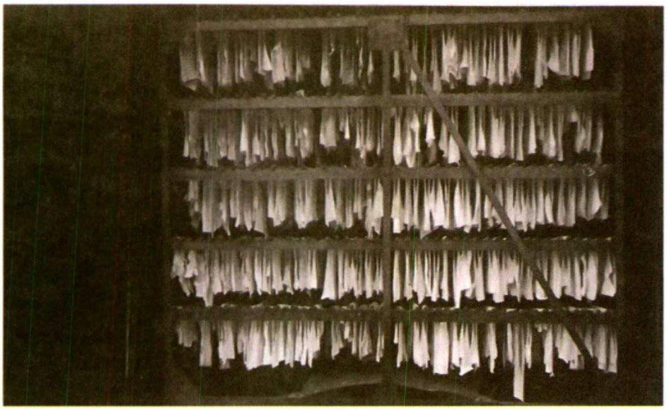


(c) Solar-powered smokehouse

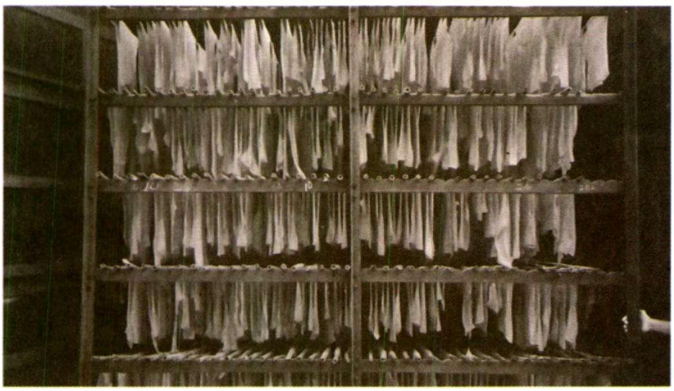
Figure 10.19 Various designs of smokehouse



(a) Putting fresh USS into smokehouse



(b) Smoking in progress



(c) Removing RSS from smokehouse

Figure 10.20 Smoking of USS

GRADING OF RSS

RSS is graded to determine its quality. The different quality is based on the specifications of each grade agreed upon internationally. Quality depends on the defects found in the RSS that is being graded. This in turn determines its value in terms of price.

Defects in RSS

The defects that are found in RSS mostly occur during processing. However, this is not realised until the rubber sheet (USS) produced is dried by smoking. The quality of RSS is determined by the defects. The following are the types of defect found in RSS, their causes and remedies.

Air bubbles. Small pinhead bubbles are found along the edge of the RSS and some are in patches or clusters anywhere over the sheet, while bubbles of irregular sizes are dotted all over the sheet. There are also the large bubbles. The small pinhead bubbles are caused by incorrect amount of acid not being satisfactorily mixed with the latex during processing. The clustered bubbles are caused by latex fermentation resulting from the use of contaminated utensils or dirty water. The irregular size dispersed bubbles are also caused by latex fermentation before and during latex collection, while the large bubbles originate in the smokehouse. The correct amount of formic acid must be ascertained to coagulate the latex after standardisation. The diluted acid is added to the latex very showly with even stirring. Avoid fermentation of latex by practising strict cleanliness and using anticoagulant where necessary.

Dirt, specks, bark and sand. These can be seen when the RSS is held against light. These are due to non-observance of cleanliness requirements when handling latex. Latex may not have been strained properly or dirty water has been used. Latex must be diluted with clean water and allowed a few minutes rest for the impurities to settle and then strained through a suitable strainer, as described earlier. Latex must, at all stages, be kept covered.

Rust. Brownish deposit is seen on the RSS. Sometimes, it is not clearly seen until the sheet is stretched or scratched. This is caused by keeping the freshly milled USS in poorly ventilated place overnight, or the sheets not being adequately washed during milling. It can also be due to low temperature and bad ventilation in the smokehouse during the early stage of curing or drying. During milling, the sheets must be washed in clean water. Freshly milled sheets or USS must be hung individually to drip in a shaded clean and well ventilated place. Proper temperature control and ventilation must be maintained during smoking.

Mould. Patches of greyish fungal growth can be seen on the rubber sheet. This is normally favoured by humid conditions. Rubber sheets that are to be dried in the smokehouse must be washed off any mould growth over them. If the mould infection occurs in the smokehouse, ventilation must be improved and the temperature should not fall below 50 °C. If the mould growth occurs during storage, ventilation of the store must be improved and the rubber sheets should not be stacked directly on the cement floor. Sometimes the poles where the USS are hung in the smokehouse have mould growing on them and this in turn infects the USS. Poles must be assured mould-free before use.

Greasy sticky surface. The surface of the RSS is sticky when touched. This can be due to excessive use of acid or sodium sulphite in latex. Insufficient washing of the sheets during milling can also cause this. The use of firewood producing excessive smoke but low heat can also be a cause. Correct amount of acid or sodium sulphite should be used. There must be adequate washing of the sheet during milling or soaking at the end of the line. Suitable fuel must always be used when drying USS, such as rubber wood of 50-100% dry.

Dark patches. Irregular shaped dark and light coloured patches can be seen over the RSS. This can be caused by surface oxidation brought about by the action of oxidising enzymes in the latex. Stacking of wet USS can also lead to these. As soon as latex coagulates, either in the coagulating tank or pan, clean water must be poured into them to keep the coagulum submerged. Wet USS should not be stacked, but should be hung individually to drip.

Blisters. Cracks or microcracks can be seen over the sheet. This can be caused by the froth remaining on the surface of the latex during coagulation. They can also be due to defective roller presses. All froths formed on the latex surface must be removed. The surface of the roller presses must be in smooth condition at all times.

Thickness or thick ends. Thick portions that are found on the RSS normally occur during machining due to overlappings and foldings. They usually do not respond to curing or drying in the normal period of time. The gap between the roller presses must be of adequate width so that the sheet can easily pass through them. The sheet must be rolled to 4 mm thickness.

RSS Specifications

The value and price of RSS are influenced by its grade on quality. For example, the price of RSS at the Kuala Lumpur market in March 1995 is shown in *Table 10.11*. It shows that the higher the quality of the RSS, the higher is the grade and the higher is the price. The price difference between RSS No 1 and RSS No 5 is 17 sen per kilogramme. Both grades are processed from naturally clean latex obtained from the trees. Unsatisfactory handling and processing technique of the latex caused the drop in quality and grade and consequently, the income.

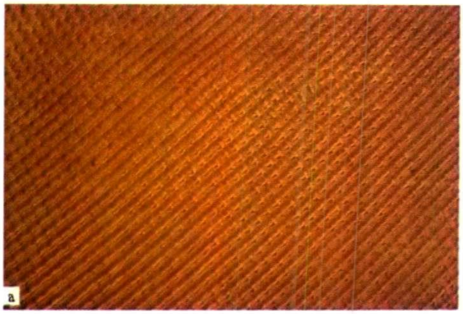
TABLE 10.11 PRICE OF RSS (SEN/KG)

Grade of RSS	Price	Difference	Total Differences
RSS No 1	462.00		
RSS No 2	458.50	3.50	
RSS No 3	457.00	1.50	17.00
RSS No 4	450.00	7.00	
RSS No 5	445.00	5.00	

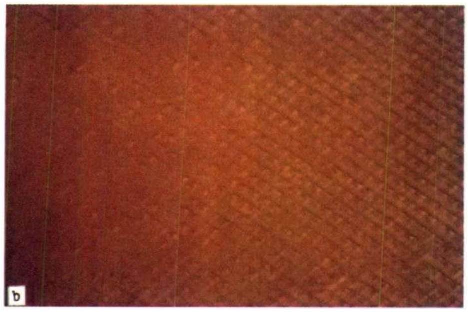
RSS is graded according to its appearance of physical conditions which were described earlier. Currently, there are six grades of quality controlled by the International Rubber Quality and Packing Conference (IRQPC). They are RSS No 1X , 1,2,3,4 and 5. The following are the specifications of the different grades.

RSS No 1X. This type of rubber is produced under conditions in which the process is strictly controlled. The sheet must be dry, clean, strong and evenly smoked. There should be no oxidised spot, foreign substance, mould, blemish, speck, rust, blister, large bubble and translucent stain. Very slight traces of dry mould on the wrapping sheets during delivery are permissible. The sheet should not be sticky, undercured, oversmoked, opaque and burnt. Scattered pinhead bubbles are permissible. There is no international master sample for this grade.

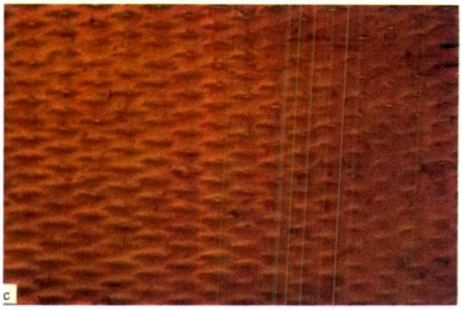
RRS No 1. The sheet must be dry, clean, strong, and evenly smoked. There should be no oxidised spot, foreingn substance, mould, blemish, rust, blister, large bubble and translucent stain. Very slight dry mould on the wrapping sheets are permissible. Scattered pinhead bubbles and slight specks are permissible too. The sheet should not be sticky, undercured, oversmoked, opaque and burnt (*Figure 10.21a*).



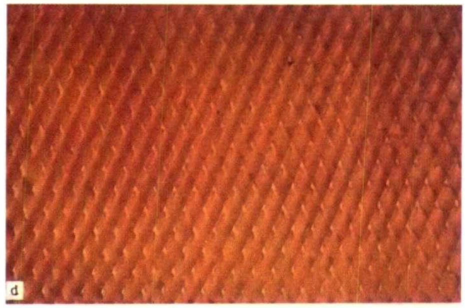
(a) RSS No 1



(b) RSS No 2



(c) RSS No 3



(d) RSS No 4

(e) RSS No 5

Figure 10.21 Grade of RSS

RSS No 2. The sheet must be dry, clean, strong, and evenly smoked. There should be no oxidised spot, foreign substance, mould, blemish, blister, large bubble and translucent stain. The sheet should not be sticky, undercured, oversmoked, opaque and burnt. Scattered pinhead bubbles and slight amount of specks are permissible (*Figure 10.21b*). If dry mould and rust are found on more than 5% of the bales inspected, they can become the basis for objection.

RSS No 3. The sheet should be dry, clean, strong and evenly smoked. There should be no oxidised spot, foreign substance, mould, blister, large bubble and translucent stain. The sheet should not be sticky, undercured, oversmoked, opaque and burnt. Scattered pinhead bubbles, slight amount of specks and blemishes are permissible *(Figure 10.21c)*. If dry mould and rust are extensively found on more than 10% of the bales inspected, they can become the basis for objection.

RSS No 4. The sheet should be dry and evenly smoked. There should be no oxidised spot, foreign substance, mould, blister and large bubble. The sheet should not be undercured and burnt. Slight amount of stickiness, oversmoking, blemishes, specks and rusts are permissible. Opaque, pinhead bubbles and translucent stains are also permissible *(Figure 10.21d)*. If dry mould and rust are extensively found on more than 20% of the bales inspected, they can become the basis for objection.

RSS No 5. The sheet should be dry and evenly smoked. There should be no oxidised spot and foreign substance and mould. The sheet should not be burnt. Slight amount of stickiness, blemishes and blisters are permissible. Slightly undercured sheet is permissible too. Oversmoked sheet, specks, rusts, pinhead bubbles, large bubbles and translucent stains are also permissible *(Figure 10.21e)*. If dry mould and rust are extensively found on more than 30% of the bales inspected, they can become the basis for objection.

Method of Grading

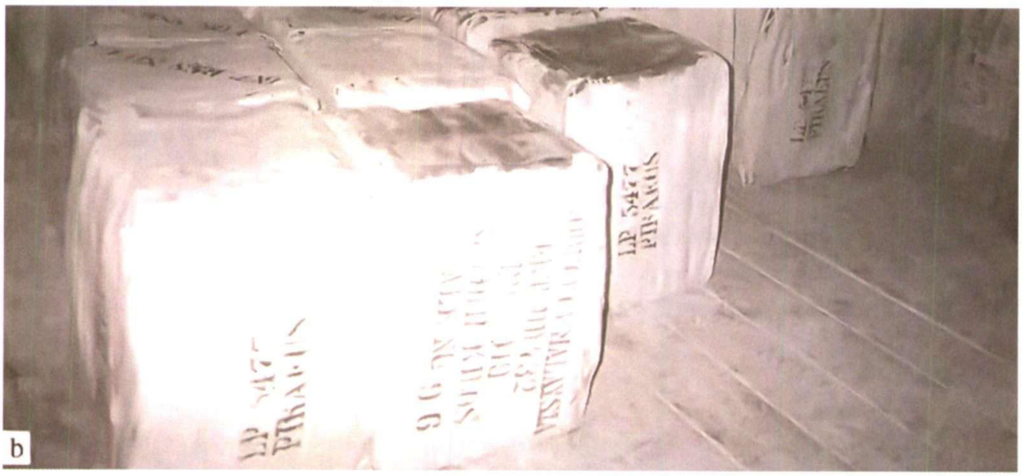
RSS is graded by visual means. The sheet is held against the light and grading is done by just looking at it, taking into account the amount of defects and foreign substances found on it, based on the above specifications. The grader is allowed to carry out limited removal of the foreign substances or defects on the sheet to raise its quality. The small pieces of rubber removed are known as cuttings and they are collected and valued at slightly below RSS No 5. Although there are official samples of all the grades (except RSS No IX), this method of visual grading can give rise to a lot of objections on the part of the consumers, as different graders may have different observations and findings.

Baling of RSS

RSS are packed without wrapping in bales of 53 cm x 48 cm x 48 cm with a maximum weight of 111.1 kg. After weighing, ten pieces of the RSS are set aside for use as wrappers. Talcum powder is spread inside the baling box or frame so that the sheets do not stick to it. RSS are arranged neatly in layers in the box and then placed under a half-tonne press for 10 minutes. The resultant bale is then wrapped with the ten pieces of RSS previously set aside. They are stuck on by piercing a sharp metal piece into the bale. Being rubber, they stick very well. Each bale is painted with bale coating solution to facilitate labelling *(Figure 10.22)*. The solution can be prepared by soaking 1 kg RSS (RSS No 1 cuttings can be used) in 17 litres mineral turpentine. When it is completely dissolved, further 8.8 litres of mineral turpentine is added to form a stock solution. At the time of application, the stock solution is further diluted with 54 litres of the same solvent. Then 7.8 kg of talcum powder is added and thoroughly stirred. This formulation is sufficient for 330 bales.

a

(a) RSS packed into 111.1 kg bales



b

(b) RSS bales coated, stencilled and ready for shipment

Figure 10.22. RSS bales

PRODUCTION OF BLOCK RUBBER

Block rubber production is another process of NR. Considered as modern as opposed to the conventional RSS, it was first introduced in 1965. It can be produced from both latex and field coagula, or a blend of both. The process involves the coagula to be broken up into small bits or crumbs, dried by hot air through a diesel-fired dryer, technically graded, baled and efficiently packed. The process facilitates the maximum removal of dirt content in rubber, guarantees cleanliness of the product at all stages (from the producing factory to the consuming factory) and offers a choice to the consumers as to the grade or type of rubber available. It has been gaining popularity from the consumers since 1990 and by 1993, 76.6% of the Malaysian rubber was produced in this form. Block rubber is exported under the SMR scheme, and currently there are nine grades, namely SMR CV60, SMR CV50, SMR L, SMR 5, SMR GP, SMR 10CV, SMR 10, SMR 20CV and SMR 20. Unlike USS, block rubber is only processed in bulk.

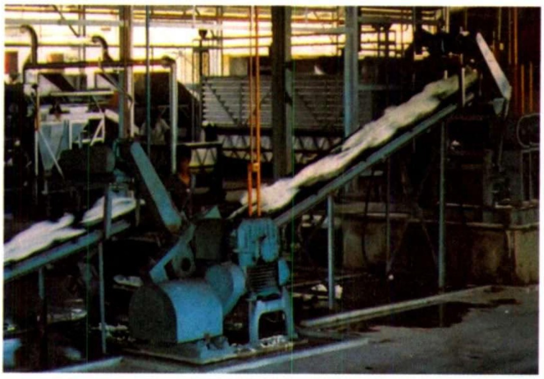
Block Rubber From Latex

Field latex is bulked in a bulking tank and thoroughly stirred. Suitable monel-metal gauze strainer is used when transferring the latex. The DRC of the latex is determined to calculate the quantity of chemicals to be added *(Table 10.12)*.

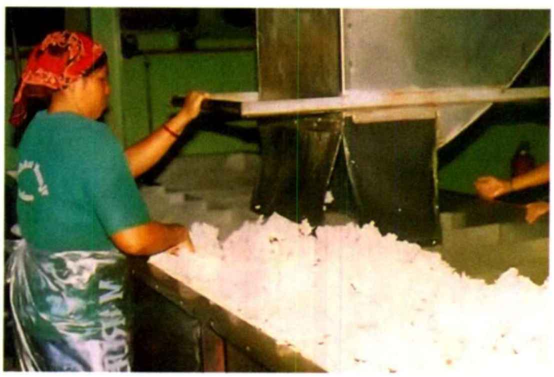
TABLE 10.12 CHEMICALS USED IN BLOCK RUBBER (SMR) PRODUCTION (PERCENTAGE OF DRC WEIGHT OF LATEX)

Types of chemical	SMR CV60	SMR CV50	SMR L	SMR 5	SMR GP	SMR 10CV	SMR 10	SMR 20CV	SMR 20
	Latex			RSS or USS	Latex+RSS or USS+ field coagulum	Field coagulum			
Sodium metabisulphite	0.04	0.04	0.04	-	-	-	-	-	-
Hydroxylamine neutral sulphate	0.15	0.15	-	-	0.16	0.2	-	0.2	-

The chemicals are first mixed with sufficient volume of water or latex and then poured into the bulking tank and thoroughly stirred. The latex is transferred into the coagulating tank or pit, and coagulated with 2% formic acid, the quantity depending on the titration value to coagulate the latex at pH 5.2. The diluted acid is slowly poured into the latex and evenly stirred. If a coagulating pit is used, the latex and the acid can be released into it simultaneously, after making proper adjustment to their rates of flow. When a clear serum has been formed over the coagulum, the tank (or pit) is flooded with clean water to submerge the coagulum. Coagulum slabs produced by pit coagulation are thick and must first go through a machine to reduce the thickness. They are then passed through two sets of crepers, and then through a shredder or extruder to break them into fine crumbs. All through the milling process, water is continuously dripped over the crepes. The crumbs are again washed and then placed in dryer boxes for dripping and later put into the drying chamber for four hours. The crumbs are dried with heat at 110 °C in an oil- or gas-fired dryer. The dried crumbs are weighed to 33 1/3 kg lots. They are then pressed to form compact bales with dimensions of 675 mm x 330 mm x 170 mm. Samples from 10% of each day's production are taken to determine the grade technically *(Table 10.13)*. The bales are wrapped in transparent polythene sheet of 0.03 mm to accommodate thirty bales with a total weight of 1 tonne or 1,425 mm x 1,100 mm x 1,080 mm for thirty six bales at 1.2 tonne according to request. There are also request for special polythene shrink wrapping packings with wooden pallet used as the base *(Figure 10.23)*.



(a) Creping and crumbing of coagulum



(b) Placing crumbs in dryer box

(c) Dried crumbs out of oven

(d) Baling

(e) Packing of rubber bales into pallet ready
for export

Figure 10.23 Processing of block rubber

Block Rubber from Field Coagula

The field coagula are first soaked in water for some time to soften and pre-clean them, and then fed into size-reducing machine such as the prebreaker or granulator. The rubber is then passed through four sets of creping machines. During the last stage of creping, crumbing agent (at 0.05% of its DRC) is dripped over the crepes. The crepes are then put into the shredder or extruder. All through the milling process, clean water is continuously dripped over the crepes. The fine crumbs produced are washed, dried, graded and packed in the usual manner. Due to the higher dirt content of the raw materials, field coagula are only suitable for the SMR 10 and 20 grades.

Block Rubber from Latex, USS or RSS and Field Coagula

This is a blending and coagulation process. The raw materials are 30% latex, 30% USS (or RSS) and 40% field coagula. This ratio is according to their DRC weights.

The percentage of USS (or RSS) and field coagula are only determined after creping them. The field coagula are pre-cleaned and milled into a blanket crepe. USS (or RSS) are also milled into a blanket crepe. Both types of blanket are then blended by passing them through four sets of creping machines. During the final stage, crumbing agent at 0.05% of its DRC weight is applied on the crepe. The crepe is then put through the shredder or granulator. The fine crumbs produced are washed and placed in the coagulating tank or pit. In the meantime, the 30% latex component is prepared in a bulking tank. Crumbing agent at 0.05% from the DRC weight of the latex and hydroxylamine neutral sulphate at 0.15% from the DRC weight of all the raw materials are mixed into the latex and thoroughly stirred. The latex is then transferred into the coagulation tank (or pit) containing crumbs of the other raw materials, together with 2% formic acid, the quantity of which has been adjusted. The resultant coagulum slabs are creped, crumbed, washed, dried, graded and packed in the usual manner. This type of rubber is graded as SMR GP.

PRODUCTION OF LATEX CONCENTRATES

Not at all rubber products can be made from sheet or block rubber. There are also products, such as dipped, cellular or foam rubber goods and others that require latex as the raw material. This necessitates transport of latex to far away destinations to reach the consumers. To reduce packing, storage, and transportation costs, latex must be concentrated to reduce the water content which forms the bulk of the latex but having no monetary value. Besides, high DRC latex is also required for the manufacture of latex

TABLE 10.13 BLOCK SMR SPECIFICATIONS

Parameter	SMR CV 60	SMR CV 50	SMR L	SMR 5*	SMR GP	SMR 10CV	SMR 10	SMR 20CV	SMR 20
	Latex			USS, RSS or ADS	Latex + RSS or USS + field coagulum	Field coagulum			
Dirt (max, % wt)	0.02	0.02	0.02	0.05	0.08	0.08	0.08	0.08	0.08
Ash (max, % wt)	0.50	0.50	0.50	0.60	0.75	0.75	0.75	0.75	0.75
Nitrogen (max, % wt)	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Volatile matter (max, % wt)	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Wallace rapid plasticity (Po)									
(min)	-	-	3/5	30	-	-	30	-	30
PRI (min,%)b	60	60	60	60	50	50	50	40	40
Lovibond colour:									
invidual value (max)	-	-	6.0	-	-	-	-	-	-
range (max)	-	-	2.0	-	-	-	-	-	-
Mooney viscosity:									
ML (1'+4")100°C°	60 ± 5	50 ± 5	-	-	655(+7,-5)	c	-	c	-
Cure[d]	R	R	R	-	R	R	-	R	-
Colour coding marker	Black	Black	Light green	Light green	Blue	Magenta	Brown	Yellow	Red
Plastic wrap colour	Trans-parent	Trans-parent	Trans-parent	Trans-parent	Transparent	Trans-parent	Trans-parent	Trans-parent	Trans-parent
Plastic strip colour	Orange	Orange	Trans-parent	Opaque white	Opaque white	Opaque white	Opaque white	Opaque white	Opaque white

[a]Two sub-grade of SMR 5 are SMR 5RSS and SMR 5ADS, which are prepared by direct baling of RSS and ADS, respectively.
[b]Special producer limits and related controls are also imposed by the MRB to provide additional safeguards.
[c]The Mooney viscosities of SMR 10CV and SMR 20CV are at present not of specification status. They are, however, controlled at the producer end to 60(+7,-5) for SMR 10CV and 65(+7,-5) for SMR 20CV.
[d]Rheograph and cure test data (delta torque, optimum cure time and scorch) are provided.

products. In 2007, Malaysia produced 176,363 tonnes of latex concentrates, which was about 14.7% of the annual rubber production.

To obtain high quality latex concentrate, proper preservation of the latex in the field is very important. Ammonia at 0.3% is normally used as an anticoagulant, as is found to be very effective in preventing bacterial growth in latex. Bacteria can cause the development of VFA in latex. The VFA number of field latex indicates the degree of biodegradation which has taken place. Lower VFA number means the latex has been well preserved and is suitable for concentration. A well preserved field latex will have a VFA number of between 0.02 and 0.04. Latex with VFA number exceeding 0.05 is not suitable for concentration. Another factor which is also important is the DRC of the latex. Latex of below 25% DRC is unsuitable for concentration. For optimum processing efficiency, latex with a minimum of 30% DRC is required.

In the production of latex concentrates, the field latex is transferred into a bulking tank through suitable monel-metal gauze strainer. After the necessary tests have been made, the latex is transferred into a settling tank overnight to settle all its impurities. There are three methods by which natural rubber latex can be concentrated. They are the centrifugation, the creaming and the evaporation process. Among them, the centrifugation process is widely practised in Malaysia.

Centrifugation

The most common latex centrifuge machine is the *Alfa Laval type (Figure 10.24).* The basic principle of this process involves the breaking up of the latex by rotating it inside several conical discs using a rotating bowl at a high speed of 7,000 rpm.

This results in the separation of the lighter rubber particles from the denser components. The concentrated latex of about 60% DRC moves in towards the centre of rotation, while the skim part of about 5% DRC moves outwards. The latex concentrate and the skim latex then go through separate channels into two gullies where they are collected. When completed, the latex concentrate is again preserved. There are five preservative systems for latex concentrates *(Table 10.14).*

Sometimes, it is also important to enhance the mechanical stability time (MST) of the latex to increase its resistance against mechanical shearing during subsequent pumping and stirring. For this purpose, lauric acid or ammonium laurate is used at 0.01-0.05%. Overboosting is not recommended as it can cause problems in latex destabilisation at the consumer's factory. MST builds up during storage and this must be considered when

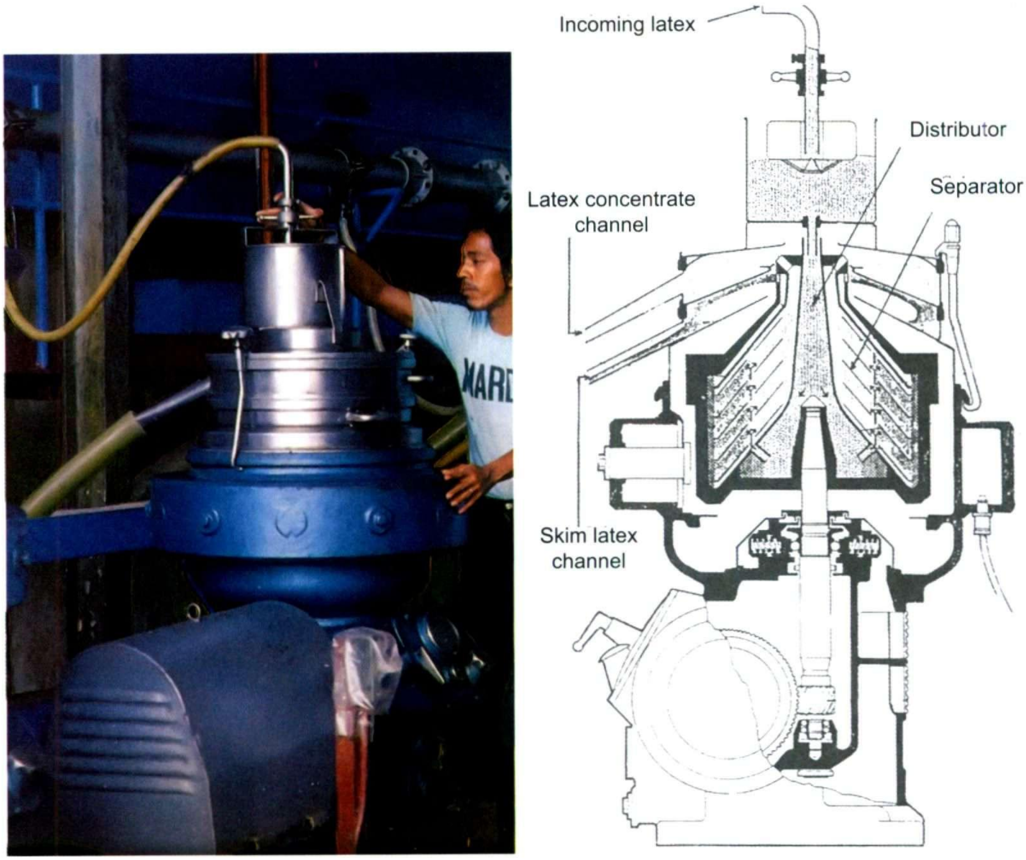


Figure 10.24 *Alfa Laval* latex centrifuge machine

TABLE 10.14 PRESERVATIVE SYSTEMS FOR LATEX CONCENTRATES

System	Preservative
HA	0.7% ammonia
LA-SPP	0.2% ammonia + 0.2%SPP
LA-BA	0.02% ammonia + 0.2% boric acid + 0.05% lauric acid
LA-ZDC	0.2% ammonia + 0.1% ZDC + lauric acid
LA-TZ	0.2% ammonia + 0.013% ZnO + 0.05% lauric acid

determining the exact level of lauric acid to be used. The consumers are more concerned with the supply of latex concentrates that comply with specifications. Therefore, each consignment of latex concentrate must have the following specifications as shown in *Table 10.16*. Latex concentrates are packed in drums or tanks before shipment.

TABLE 10.15 BASIC TEST AND SPECIFICATION LIMITS OF CENTRIFUGED LATEX CONCENTRATE

Test properties	ISO 2004 specification
Total solids content (%, min)	61.5
DRC (%, min)	60.0
Alkalinity (g ammonia per 100 g water)	1.6 min (HA) or 0.8 max (LA)
Mechanical stability time (s, min)	650
VFA number (max)	0.20 or as agreed by consumer and pruducer
Potassium hydroxide (max)	1.00 or as agreed by consumer and pruducer

Creaming Process

In this process, a compound that acts as a creaming agent is used to cause the rubber particles in latex to agglomerate loosely into larger groups which rise to the surface to form a cream. The most common creaming agent is ammonium alginate. The process in briefly described by the following flow diagram (*Figure 10.25*).

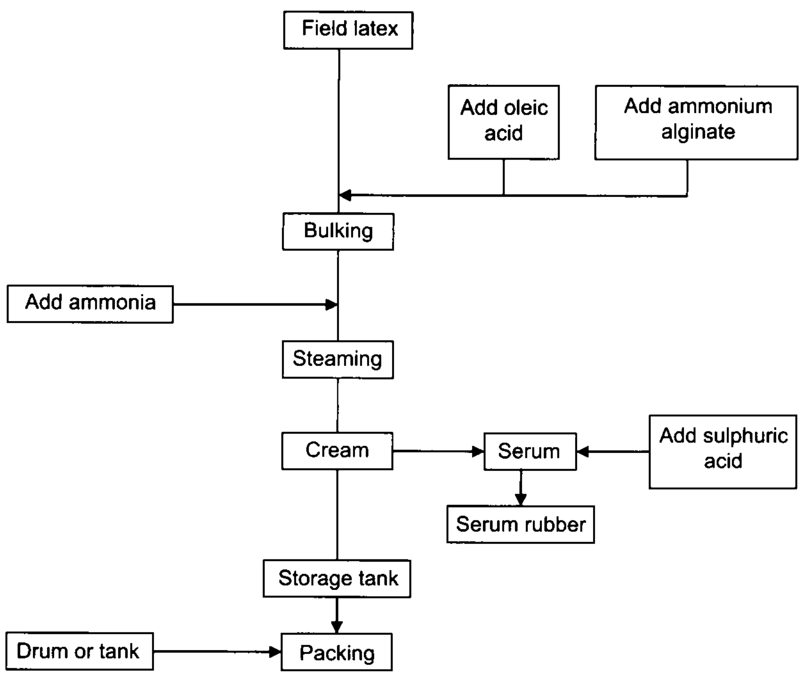


Figure 10.25 Flow diagram of the creaming process

Evaporation Process

This process involves circulating the latex through a tubular heat exchanger in a specially designed evaporating unit. The evaporation is carried out in a suitable chamber under reduced pressure. Recycling the partially concentrated latex is necessary until the desired DRC is achieved. Ammonia is commonly used as preservative in this process. The concentrated latex is treated and packed in the usual manner.

Modified Latex Concentrates

Besides latex concentrates described above, there are also several other types of modified concentrates available for specific uses. These are briefly described below.

High DRC latex. This latex contains 64-67% DRC. It is prepared by double centrifugation as described earlier. To obtain such latex, a specially modified bowl with specially adjusted sizes of feed tubes and skim screws used in the centrifuge machine. Its latex properties are suitable in adhesives preparations and dipped products.

Purified latex. This latex contains low non-rubber solids content. It is prepared by two or three centrifugations. The reduction of non-rubber solids, especially proteins, in the latex, renders the latex clean with low water absorption properties. This can offer special advantage to products like electricians' gloves, insulators, human body parts and prophylactics.

Prevulcanised latex. This latex is prepared by heating latex concentrate with vulcanising ingredients. When using such latex in product manufacture, vulcanisation of the finished product is not required. Therefore, the compounding process can be simplified. This latex is suitable in the manufacture of dipped and cast goods, textile combining and carpet backing compounds.

Freez-thaw-stabilised (FTS) latex. When concentrated latex is frozen to below 0 °C, colloidal destabilisation takes place, and when the latex is thawed it becomes viscous and unstable. If the frozen condition is prolonged, coagulation of the latex may take place. FTS latex can be prepared by adding 0.2% of latex weight sodium salicylate and 0.04-0.05% of latex weight lauric acid. Although these chemicals do not prevent freezing, they can enhance latex stability during freezing and enables the latex to regain fluidity on thawing.

FTS latex is suitable for storage and can be used during the winter period in temperate countries.

Methyl-methacrylate (MG) latex. When methyl-methacrylate is polymerised in NR latex using a free radical catalyst, a large proportion of the polymethylmethacrylate that is formed, is grafted chemically to the molecular chain of NR. Two such types of latex are being produced, with the trade names of *Heveaplus MG 30* and *MG 49*, which contain 30% and 49% by weight, methylmethacrylate, respectively. They are supplied at 40-55% total solids content and have several specific uses, such as adhesives for bonding dissimilar surfaces and reinforcing agents in certain applications.

Low constant viscosity (LCV) latex. This is standard latex concentrate which is prepared from latex of soft clones and treated with 0.15 phr of hydroxylamine. Addition of hydroxylamine to the concentrate retards the rate of increase in viscosity of the rubber in the latex during storage. LCV latex is produced to meet a Mooney Viscosity of not greater than ninety units when reaching the consumer. The main advantage of such latex is in the application of adhesives, in which the low viscosity permits the use of lower levels of tackifying resins in the formulation of the adhesives.

Skim Latex

In the process of latex centrifugation, the diluted part known as skim is separated. This contains 4-7% DRC. Part of the skim is used locally in the mixing process with other rubbers. The balance is processed into skim crepe or block rubber such as MARUB. Skim latex is high in ammonia content. Therefore, it is necessary to reduce the ammonia by allowing it to evaporate naturally. However, this process can be speeded up by the rotating-disc deammoniation system. It comprises a column through which air and skim latex are passed counter-current to one another. The column is provided with an axially positioned rotatable shaft upon which are located a number of discs. It is further provided with a series of redistribution trays located at intervals along its length. The latex showers from its feed distribution tray on the rotating disc below. The latex flowing downward, counter-current to the air flow, is dispersed by the rotating discs. Latex which splashes on the walls of the column is collected on the latex redistribution trays. Under suitable conditions, the dispersion produces fine latex droplets.

This type of aeration reduces the ammonia content to less than 0.1% w/w of skim latex, which can become autocoagulated in a few days. This can also be speeded up by using sulphuric acid as the coagulant. The quantity of acid required is calculated stoichiometrically to neutralise the ammonia. The acid is added to the latex as a 10% w/v aqueous solution and quickly stirred. Coagulation takes place in a few minutes. The coagulum produced is washed, creped, crumbed, dried and packed as in other block rubber production.

Although the properties of skim rubber vary from different sources, the production from each factory is usually uniform. Test analysis normally shows the following values. *(Table 10.16).*

TABLE 10.16 TEST ANALYSIS OF SKIM RUBBER

Properties	Typical value
Dirt (max, % wt)	0.05
Ash (max, % wt)	1.00
Nitrogen (max, % wt)	1.00-4.00
Acetone (max, % wt)	3-15
Wallace plasticity (Po)	35-45
PRI	40
MOD (kg cm^{-2})	Up to 15
Colour	Varies
RHC (min, %)	90-60

GLOSSARY

Abdomen
the region of the body of a vertebrate that contains the viscera other than the heart and the lung; in mammals it is separated from the thorax

Acid
any substance that dissociates to yield a sour corrosive solution containing hydrogen ions, having a pH of less than 7 and turning litmus red

Acid equivalent
amount of active ingredient expressed in terms of its parents

Active ingredient
the component in a chemical formulation that gives the effect

Alkali
a soluble base or solution of a base, a soluble mineral salt that occurs in arid soils and some natural waters

Alluvium
a fine-grained fertile soil consisting of mud, silt and sand deposited by flowing water on flood plains, in river beds and in estuaries

Amine
an organic base formed by replacing one or more of the hydrogen atoms of ammonia by organic groups

Anther
the terminal part of a stamen consisting of two lobes, each containing two sacs in which the pollen matures

Anticoagulant
a chemical that can delay the coagulation of latex

Aqueous concentrate
a concentrated solution that forms a solution when water is added and stirred

Aqueous solution
a solution that contains water

Arboricide
a chemical that kills trees

Aromatic compound
a compound obtained from benzene hydrocarbon

Arthropod
any invertebrate of the phylum Arthropoda, having jointed limbs, a segmented body and an exoskeleton made of chitin

Auxine
any of the various plant hormones, such as indoleacetic acid that promotes growth and controls fruit and flower development

Avenue planting
a planting design in which the inter-row distance is very wide-more than a rectangle but less than a hedge

Axillary bud
the bud situated between the stem and the leaf axil

Bacteria
a minute one-cell plant without chlorophyll

Baffle
a plate or mechanical divide to restrain or regulate the flow of fluid, smoke, light, or sound such as the one found in the smokehouse furnace

Bare or exposed soil
a soil without any cover plant growing over its surface

Bark gauge
an instrument used for measuring the thickness of the bark of the rubber tree

Basic slag
a furnace slag produce in steel making, containing large amounts of calcium phosphate used in a fertilizer

Biscuit
a rubber sample used in determining the dry weight of field latex by the laboratory and chee methods

Blanket hectare
a full hectare of an area

Blight
any plant disease characterised by weathering and shrivelling but without rotting

Blind contour
a contour line that does not begin from the base line, sometimes known as filler contour line

Breeding
the process of bearing offsprings in plants and animals; reproduction

Budded stump
a stock plant which has been successfully budded and extracted for transplanting

Bud grafting
taking a bud from a selected tree and allowing it to grow on a stock plant; it is one of the methods of vegetative propagation

Budpatch
a bud slip which has been stripped of its wood, trimmed and ready to be inserted in the stock plant for the purpose of budgrafting

Bud slip
a bud which has been sliced with part of the wood from its budstick, from it a budpatch is obtained for budgrafting

Buttress
a root that supports the trunk of a tree usually growing from the stem

Calibration
markings on a scale of measuring instruments so that the reading can be made in appropriate unit

Callus
a mass of hard protective tissue produced in woody plants at the site of an injury

Cambium
a meristem that increases the girth of stems and roots by producing additional xylem and phloem

Carpel
the female reproductive organ of flowering plants consisting of an ovary style and stigma the carpals are separate or fused to form a single pistil

Cell
the smallest unit of an organism the carpals that is able to function independently it consist of a nucleus containing the genetic material

Cell nucleus
the source of life in a cell

Centrifuge
rotating machines that separate liquids from solids or dispersions of and liquid in another by centrifugal force action, such as the one used for concentrating latex

Ceramic
a hard brittle material by firing clay and similar substance

Cess
duty or tax

Chloroplast
a plastid containing chlorophyll and other pigments occurring in plant that carry out photosynthesis

Chromosome
any of the microscopic rod-shaped structures that appear in a cell nucleus during cell division consisting of nucleoprotein arranged into units (genes) that are responsible for the transmission of hereditary characteristics

Classic
composed of fragments of pre-existing rocks

Clone
a group of cell of the same genetic constitution that are descended from a common ancestor by vegetative reproduction

Coagulation
causing a change from liquid to a soft solid mass, e.g coagulation of latex to form coagulum

Coagulum
latex which has coagulated

Collar
the part of a plant between the base of the stem and the tap root

Colloidal
a mixture having particles of one component with diameters between 10^{-7} m and 10^{-9} m, suspended in continuous phase of another component; the mixture has properties between those of a solution and a fine suspension

Columnar
elongated soil structure

Compact
closely packed together solid and firm such as compact soil

Composite
composed of separate parts

Compost
a mixture of organic residues for use as fertiliser

Configuration
the shape of a molecule as determined by the arrangement of its atoms

Conservation
protecting from damage or loss e.g. soil conservation

Constituent
a part of a whole component

Constraint
restrictive condition

Contact herbicide
a chemical that kills herbs by touch

Contour line
a line drawn on a map showing points of the same height from sea level

Core stump
a large budded plant which has been extracted with its roots enclosed in a soil core still intact for transplanting

Cortex
the unspecialised tissue in plant stems and root between the vascular bundles and the epidermis the outer layer of a part such as the bark of a stem

Crepe
having ridged or crinkled surface such as crepe rubber

Crotch
a forked region formed by the junction of two members such as the branch crotch of a plant

Crown
the top section of a plant or tree which consists of the branches and the leaves

Cumulative effect
growing in quantity, strength, of effect by successive or gradual steps

Defoliant
a chemical used in shedding the leaves of plants

Degraded or **exhausted soil**
soil which has been overused by improper cultivation

Diagnostic
of relating to, or of value in diagnose any symptom that provides evidence for making a specific diagnosis

Dicotyledon
any flowering plant of the Dicotyledonea having two embryonic seed leaves

Distillation
the process of evaporating a liquid and condensing its vapour

Dormant bud
a bud which has not yet developed into a shoot

Dorsal
of relating to or situated on the side of an organ that is directed away from the axis

Drainage area
the area of bark in which latex is drawn when tapping is done

Electrolyte
a solution or molten substance that conducts electricity

Element deficiency
lacking in any nutrient in plants and animals

Ellipse
a closed conic section shaped like a flattened circle and formed by an inclined plane that does not cut the base of the cone

Empirical
derived from or relating to experiment and observation rather than theory

Emulsion
a colloidal in which both phases are liquids like oil-in-water emulsion

Emulsifiable concentrate
a concentrated solution and emulsifier in an organic solvent that will form an emulsion spontaneously when water is added or stirred

Endemic
present within a localised or peculiar to plant in an area such as an endemic disease

Environmax
pertaining to a particular area or locality

Environment
area or surrounding

Enzyme
a group of complex proteins or conjugated proteins that are produced by living cells and act as catalysts in specific biochemical reactions.

Epical
a bud situated at top of plant

Equation
a mathematical statement that two expressions are equal

Erosion
the wearing away of soil from the earth surface by the action of water, wind , and sunlight

Evaporation
the change from a liquid or solid state to a vapour

Exudation
the release of sap from the rubber tree through the pores

Exploitation
the act of extracting latex yield from the rubber tree, which includes tapping, puncturing and stimulation

Extruder
a machine that produces moulded sections of rubber by ejection under pressure from a suitable shaped nozzle

Fertilisation
the union of male and female gametes during sexual reproduction to form a zygote

Flux
a chemical used to increase the fluidity of refining slogs in order to promote the rate of chemical reaction

Foliage
the total green leaves on a plant

Friable
easily broken up; crumbly, loose such as friable soil

Fructification
any spore-bearing structure in fungi

Fruit body
the part of a fungus in which the spores are produced

Fungicide
a chemical that kills fungi

Fungus
any plant lacking in chlorophyll, leaves, true stem and root reproduced by spores and living as saprophyte or parasite

Furnace
an enclosed chamber in which heat in produced by burning fuel, such as wood

Gangue
valueless and undesirable material such as quartz in small quantities in an ore

Genesis
a beginning of origin and anything

Genetic
a leaf of a plant turning yellow due to its genes or heredity

Geology
the scientific study of the origin, history , structure and composition of the earth

Gleyzation
a soil-forming process which results in the development of bluish-grey compact sticky soils known as gluey soils

Globule
a small drop of liquid

Gouge
a tapping knife that cuts by pushing

Granulator
a machine that produces granulated products

Gutta percha
any of several tropical trees of the sapotaceous genera *Palaquium* and *Payena.*

Gynoceum
the carpels of a powering plants collectively

Habitat
the natural home of a plant or animal

Hedge planting
a planting design in which the inter-rows are very far apart, more than a avenue

Herb
a seed bearing plant whose aerial parts do not persist above ground at the end of the growing season; herbaceous plant

Herbaceous
related to plant that are fleshy as opposed to woody

Heterogeneous
composed of unrelated or differing parts or elements not of the same kind or type

Horizon
a layer in a soil profile having particular characteristics

Hormone
an organic compound produced by a plant that is essential for growth

Host plant
a plant that nourishes and supports a parasite

Humus
a dark brown or black colloidal mass or partially decomposed organic matter in the soil and therefore important for plant growth

Hybrid
a plant or animal resulting from a cross between genetically unlike individuals

Immaturity
not fully grown or developed; in rubber it is young and not yet ready for tapping

Immunity
the ability of an organism to resist disease by producing its own antibodies or by inoculation

Inarching or **approach grafting**
to graft a plant by uniting stock and scion while both are growing independently

Included bark
the bark of a plant that grows into a crack at the branch fork, where water can seep in, thus causing rot and stem split

Inert ingredient
inactive component of a mixture

Inland soil
soil away from the coastal areas

Inoculate
to introduce the causative agent of a disease into the body of a plant or animal in order to induce immunity, to introduce micro-organisms, especially bacteria into a plant

Inorganic material
a material which is not organic; not having the structure or characteristic of living organisms

Input
a resource required in a production

Insect
any small air-breathing arthropod of the class Insecta, having a body divided into three – head, thorax and abdomen and three pairs of legs and in most species two pairs of wings

Insecticide
a chemical that kills insects

Integument
any outer protective layer or covering, such as a cuticle, seed coat, rind or shell

Interaction
a mutual or reciprocal action; the transfer of energy between elementary particles, between a particle and a field or between fields

Invertebrate
any animal lacking a backbone, including all species not classified as vertebrates

Ion
an electrically charged atom or group o atoms formed by the loss or gain of one or more electrons

Jebong
the tapping knife that cuts by pulling

Jet
a thin stream of liquid or gas forced out of a small aperture or nozzle

Kink
twisted such as the twisted condition of a tree trunk

Lamella
any of the membrane in a chloroplast

Larva
an immature free living form of many animals that develops into a different adult form by metamorphosis

Latent bud
a bud which has the potential of producing a shoot but not obvious or explicit

Laterite
any of a group of residual deposits of ferric and aluminium oxides formed by weathering of rocks in tropical regions

Latex
the white fluid that oozes out of the bark of the rubber tree when inflicted

Latosol
a suborder of zonal soils, including soils formed under forested tropical humid conditions, characterised by low silica-sesquioxide ratios of the clay fractions, low base-exchange capacity of the clay content of most primary minerals, low content of soluble constituents, high degree of aggregate stability and usually having a red colour

Leach
to lose or cause to lose soluble substance by the action of percolating liquid

Leader branch
the main central branch situated between the lowest crotch and the tip of the tree

Leaf axil
the stalk connecting the leaf petiole and the stem or branch

Legume purification
removal of weeds growing within a planted legume cover crop to obtain pure legume cover

Lenticel
any of numerous pores in a stem of a wood plant allowing exchange of gases between the plant and the exterior

Lethal dosage
the amount of the active ingredient in a chemical required to kill 50% of the test animal population

Loam
soil made up of a mixture of clay, sand and decaying organic material

Logarithm
the exponent indicating the power to which a fixed number, the base must be raised to obtain a given number or variable; it is used to simplify multiplication and division

Macerator
a machine used to soften or separate raw rubber as a result of soaking

Mammal
any animal of the Mammalia, a large class of warm-blooded vertebrates having mammary glands in the female, a thoracic diaphragm and a four-chambered heart

Masterbatch
a mixture of ingredients at higher concentrations, usually for storage, which can or must be reduced (diluted) further before use, e.g. latex masterbatch treated with preservatives in the production of latex concentrates

Mature
fully grown, ripe; the rubber tree is considered matured when the trunk size reaches a girth of 45 centimetres

Medulla
the innermost part of an organ or structure; the centre part of the rubber tree stem called pith

Meniscus
the curved upper surface of a liquid standing in a tube, produced by the surface tension

Meristematic
a plant tissue responsible for growth, whose cells divide and differentiate to form the tissues and organs of the plant

Metabolism
the sum total of the chemical processes that occur in living organisms, resulting in growth, production of energy, and elimination of waste material

Metarmorphosis
the rapid transformation of a larva into an adult that occurs in certain animals, *e.g.* the stage between tadpole and frog or between chrysalis and butterfly

Micro-organism
any organism, such as bacterium, protozoan or virus of microscopic size

Micropyle
a small opening in the integument of a plant ovule through which the male gametes pass

Miscible
capable of mixing, *e.g.* alcohol is miscible with water

Mitosis
a method of cell division, in which the nucleus divides into daughter nuclei, each containing the same number of chromosomes as the parent nucleus

Modulus
a coeficient expressing a specified theory of a specified substance

Moisture
water or other liquid diffused as vapour or condensed on or in objects

Molecule
the simplest unit of a chemical compound that can exist consisting of two or more atoms held together by chemical bonds

Mollusc
any invertebrate of the phylum Mollusca, having a soft unsegmented body and often a shell, secreted by a fold of the skin (the mantle), such as snails, slugs, clams, mussels, cuttlefish, octopuses, etc.

Monel-metal
any of various corrosion-resistant alloys containing 28% copper, 69% nickel and aluminium

Monoclone
consisting only of one clone

Monomer
a compound whose molecules can join together to form a polymer

Mottling
colour with streaks or blotches of different shades in a soil, usually in water-logged areas

Mulch
dead plant and other materials spread over the soil surface, especially around planted crops to keep the soil surface cool and moist

Mycelium
the vegetative body of fungi, a mass of branching filaments (hyphae) that spread throughout the nutrient substratum

Necrosis
death of plant tissue due to disease

Noxious weeds
poisonous or harmful unwanted plants

Nozzle
a projecting pipe or spout from which fluid is discharged

Nuclei
plural form of nucleus

Nucleus
a spherical or ovoid cellular organelle, bounded by a membrane, that consists of DNA, RNA, etc., and is responsible for growth and reproduction of the cell and the transmission of hereditary material

Nutrient
any of the mineral substances that are absorbed by the roots of plant for nourishment

Optimum
a condition, degree, amount of compromise that produces the best possible result

Organic material
a material derived from plant or animal parts or organs

Organism
any living plant or animal including any bacterium or virus

Orifice
an opening or mouth into a cavity; vent; aperture, such as an orifice of a sprayer nozzle

Osmosis
the passage of solvent molecules from a less concentrated to a more concentrated solution through a semi-permeable membrane until both solutions are of the same concentration

Ovary
the hollow basal region of a carpel containing one or more ovules

Ovule
a small body in seed-bearing plants that contains the egg cell and develops into the seed after fertilisation

Oxidise
to undergo or cause to undergo a chemical reaction with oxygen, as in the formation of oxide

Ozone
a colourless gas with chlorine-like odour, formed by an electric discharge in oxygen

Parabola
a conic section formed by the intersection of a cone by a plane parallel to the generator

Parasite
a plant or animal that lives in or on another (host) from which it obtains nourishment

Parenchyma
a soft plant tissue consisting of simple thin-walled cells with intervening air spaces

Parent material
the unconsolidated and more or less chemically weathered mineral or organic matter from which the solum of soils is developed by pedogenic process

Pendant
hanging, dangling, soft, not fully developed, such as the very young rubber leaves just after the leaflet stage of growth

Perennial crop
a crop that completes its life cycle in more than two years, such as rubber

Periodic
happening or recurring at intervals; intermittent

Petiole
the stalk by which a leaf is attached to the plant; leaf stalk

Petiolule
the short stalk by which the leaf is attached to the petiole

Petrolatum substance
a translucent gelatinous substance obtained from petroleum, used as a lubricant and in medicine as an ointment base and protective dressing

Phelloderm
a layer of thin-walled cells produced by the inner surface of the cork cambium

Phellogen
the technical name for the cork cambium

Phloem
tissue in higher plants that conducts synthesised food substances to all parts of the plant

Photosynthesis
the synthesis of organic compounds from carbon dioxide and water (with the release of oxygen) using light energy absorbed by chlorophyll

Pith
the central core of unspecialised cells surrounded by conducting tissue in the stem

Planting density
the number of trees suitable for planting in a specified size area, e.g. per hectare

Planting design
the planting arrangements of trees or crops in an area

Plastid
any of various small particles in the cytoplasm of the cells of plants and some animals which contains pigments, starch oil, protein, etc.

Pneumatic
containing pressurised air as in pneumatic tyre

Pod
the seed case as distinct from the seeds

Pollarding pruning
a tree at the crown level to induce branching or to lighten the tree

Pollen
fine powdery substance produced by the anthers of seed-bearing plants, consisting of numerous fine grains containing the male gametes

Pollination
the transfer of pollen from the anther to the stigma of a flower

Polyclone
consisting of more than one clone

Polyhedron
a solid figure consisting of four or more plane faces, pairs of which meet along an edge, three or more edges meet at a vertex

Polyisoprene
polymeric forms of isoprene occurring in rubber

Polymer
a naturally occurring or synthetic compound that has large molecules made up of many relatively simple repeated units

Post-emergent herbicide
a chemical that kills herbs that are already growing

Potential of hydrogen (pH)
a measure of the acidity or alkalinity of a solution equal to the common logarithm of the reciprocal of the concentration of hydrogen ions in moles per cubic decimeter of solution; pure water has a pH of 7, acid solution less than 7 and alkaline solution greater than 7

Precipitation
a process in which a dissolved substance separates from solution as a fine suspension of solid particles

Precoagulate
latex becomes partial solid naturally, usually by bacterial action

Predator
an animal that lives by eating other animals

Pre-emergent herbicide
a chemical that kills herbs at the seed stage (before it germinates)

Premium
an amount paid as a bonus in addition to the standard rate, for excellent production

Prism
a polyhedron having parallel, polygonal, and congruent bases and sides that are parallelograms

Prismatic
concerned with, containing or produced by a prism

Profile
a vertical section of soil from the ground surface down to the parent rock showing the different horizons

Protectant
a chemical applied to any part of a plant to prevent disease infection

Protoplasm
the living contents of a cell; a complex translucent colourless colloidal substance differentiated into cytoplasm and nucleoplasm

Protozoan
any minute invertebrate of the phylum Protozoa

Prune
to cut any part of the plant, especially the branches

Pupa
an insect at an immobile nonfeeding stage of development between larva and adult, when many internal changes occur

Quicklime
calcium oxide

Quincunx
a group of five objects arranged in a shape of a rectangle with one at each of the four corners and the fifth in the centre

Radical
the root that emerges when the seed germinates

Random
not following any pre-arranged order

Relief
variation in altitude in an area; difference between the highest and lowest level of an area

Renewed or **regenerated bark**
the bark of the rubber tree which grows again after tapping it

Repellant substance
a chemical applied on trees or around the plantation to keep away pests

Residual effect
relating to or designation a residue or remainder or left over

Resistance
a plant's natural capacity to withstand disease

Retasking
reviewing or reorganising an existing work allocation to obtain a new one, such as retasking of a tapping task

Rhizome
a thick horizontal underground stem of plants whose buds develop into new plants, *e.g. Imperata cylindrica*

Rhizomorph
a root-like structure of certain fungi, consisting of a dense mass of hyphae

Rhombus
an oblique-angled parallelogram having four equal sides

Ringbarking
removing a strip of bark of a tree by making two circular cuts on the stem

Ringcutting
making a circular cut into the bark of a tree the depth of which is just up to the wood to induce branching

Road tracer
an instrument to plot points of the same level on hill slopes

Rodent
any of the relatively small placental mammals that constitute the order Rodentia, having constantly growing incisor teeth specialised for gnawing, such as rats, porcupines, etc.

Rodenticide
a chemical that kills rodents

Rogue plant
a plant of unwanted variety

Root nodule
a swelling on the root of leguminous plants that contains bacteria of the genus *Rhizobium*, capable of nitrogen fixation

Runt
the smallest and weakest plant in a group

Saprophyte
organism which obtains organic matter in solution from dead and decaying tissues of plants or animals

Saturate
to fill, soak or imbue totally

Scale bud
a bud (undeveloped shoot) without the leaf axil

Scion
a shoot or twig of a plant used to form a graft

Sediment
matter that settles to the bottom of a liquid

Serum
a clear watery fluid, especially that exuded by serous membrane

Sesquioxide
any of certain oxides whose molecules contain three atoms of O_2 for every two atoms of Cr_2O_3

Silt
a fine deposit of mud, clay, etc, especially one in a lake or river

Skim latex
the water portion of latex after concentration by centrifugation

Slag
the fused material formed during the smelting or refining of metals by combining the flux with gangue, impurities in the metal; it usually consists of a mixture of silicates with calcium, phosphorus, sulphur, etc.

Slaked lime
calcium oxide (lime) in which water has been added; calcium hydroxide

Sludge
any deposit or sediment resulting from a process, *e.g.* centrifugation of latex

Soil aggregate
a group of soil particles

Soil ped
a unit of soil structure such as an aggregate, crumb, prism, block or granule formed by natural process

Soil series
a group of soils with the same profile characteristics and formed by a parent material of the same geological origin

Spatial
of or relating to space; existing or happening in space

Species
any of the taxonomic groups into which a genus is divided; the members of which are capable of interbreeding

Spermatozoon
any of the male reproductive cells released in the semen during ejaculation, consisting of a flattened egg-shaped head, a long neck, and a whip like tail by which it moves to fertilise the female ovum

Sphere
a three-dimensional closed surface such that every point on the surface is equidistant from the centre

Spiral
one of the several plane curves formed by a point winding about a fixed point at an ever increasing distance from it

Spore
a reproductive body produced by some protozoans of many plants that develops into a new individual

Spray swath
the width covered by the liquid output of a sprayer nozzle

Standardisation
diluting field latex with water to obtain the same dry rubber content (drc) at each day's production

Static
not active or moving; stationary

Stigma
the terminal part of the ovary at the end of the style, where deposited pollen enters the gynoceum

Stimulant
a chemical or similar substance that increases physiological activity in a plant or animal

Stock plant
a plant, usually seedling, raised for vegetative propagation

Stock solution
a concentrated solution, usually for storage, which can be further diluted before use

Stoichiometric
concerned with, involving or having the exact proportions for a particular chemical reation

Straight or **single fertiliser**
a fertiliser that contains normally one major nutrient and one or more minor ones

Strip hectare
the total area occupied by rubber tree planting rows (usually of 2 m wide x total length of planting row) per hectare

Subsoil
soil below the top layer

Susceptible
prone to disease or pest attack or damage

Synthesis
the process of producing a compound by a chemical reaction or a series of reactions, usually from simpler or commonly available starting materials

Systemic herbicide
a chemical that kills herbs by translocation into the plant systems

Tailing
pruning the tap root of a plant in the soil a few days before extracting it for transplanting, this is to reduce transplanting shock on the plant

Tapping cycle or **frequency**
refers to how often tapping is done on a rubber tree, *e.g.* daily, alternate daily, third daily, etc.

Tapping task
the number of trees given to a tapper to be completely tapped in a specified time, usually a day; each day's tapping allocation

Tar-acid fungicide
a chemical that kills fungi, produced by tar obtained from coal

Tasking
allocating a work load to be completed in a specified time

Tentacle
any of various elongated flexible organs that occur near the mouth in many invertebrates and are used for feeding, grasping, etc.

Terminal
end, *eg*. terminal bud

Terracing
constructing contour steps along hill slopes

Texture
the general structure and disposition of the constituent parts such as soil structure

Thinning out
removal of unwanted (runts, diseased or defective) plants in a planted stand to reduce the density, to increase space, to enhance growth and to reduce waste

Thorax
the part of an insect's body between the head and the abdomen, which bears the wings and the legs

Titration
a measured amount of one solution is added to a known quantity of another solution until the reaction between the two is complete; if the concentration of one solution is known, that of the other can be calculated

Topography
the surface form of land or region

Toxic
poisonous, harmful or deadly

Translocated herbicide
a chemical that kills weeds by absorption of the chemical into the plant system through the stomata in the leaves

Transpiration
loss of water in a plant through the leaves by the action of sunlight

Trapezium
a quadrilateral having two parallel sides of unequal length

Turgid
swollen, disdented and rigid condition of plant cells, especially during the hours of no sunlight

Turgor or **osmotic pressure**
pressure of the cell contents against the cell wall membrane

Ultra
extreme

Undulating land
land of uneven surface

Ventral
relating to a front part of a body towards the belly or seed

Vertebrate
any chordate animal of the sub-phylum Vertebrata, characterised by a bony or cartilaginous skeleton and a well-developed brain, such as fishes, amphibians, reptiles, birds and mammals

Virgin bark
the bark of the rubber tree which has never been tapped

Viscera
the large internal organs of the body collectively, especially those in the abdominal cavity; the intestines; guts

Viscosity
the extent to which a fluid resists a tendency to flow

Volatile fatty acids
organic acids which are byproducts of bacteria digestion of the non-rubber constituents in field latex; they are undesirable as they destabilise the latex and cause precoagulation

Volatile matter
something that is readily capable of changing from liquid or solid form to a vapour

Volume/volume
when a certain liquid formulation having its liquid active ingredient given as the percentage of its volume, *eg.* sulphuric acid

Vortex
a whirling mass or motion of liquid, gas, flame, etc., such as the spiraling of water around a whirlpool

Vulcanisation
the treatment of rubber with sulphur or sulphur compounds under heat and pressure to improve its properties

Water table
the surface of the water-saturated part of the ground (soil), usually following approximately the contours of the overlying land surface

Weathering
the physical and chemical breakdown of rocks by the action of temperature and rain

Weed
an unwanted plant that competes for nutrients, space and light with the crop

Weeding
to remove weeds by physical means, such as hand pulling or manual hoeing or cutting.

Weight/volume
for a liquid formulation having a solid active ingredient.

Weight/weight
an active ingredient expressed as percentage weight for solid formulations, such as dusts, granules or powders that are wettable.

Wettable powder
a type of formulation for spraying in which a chemical is mixed with an inert carrier, the product is refined and surfactant added so that it turns into a suspension when stirred.

Whorl
a radial arrangement of leaf petioles or branches around a stem.

Wintering
annual shedding of leaves from plants during the dry period; this is nature's way of conserving water in a plant.

Woody growth
a hard-stem plant.

Wound dressing
a chemical substance which is applied to wounded or injured part of a plant.

Xylem
a plant tissue that conducts water and mineral salts from the roots to all other parts, provides mechanical support and forms the wood of trees and shrubs.

Yield
the return or profit from an investment; the product of labour or crop cultivation, *e.g.* latex is the yield of rubber crop.

Zygote
the cell resulting from the union of an ovum and a spermatozoon.

SYMBOLS

Symbols		In full
ADS	=	Air dried sheet
Ae	=	Acid equivalent
ai	=	Active ingredient
AVROS	=	Algemene Vereniging Rubberplanters' Oostkust Sumatra
B	=	Boron
BPM	=	Balai Penelitian Medan
C	=	Carbon
Ca	=	Calcium
$CalCl_2$	=	Calcium chloride
$CaCn_2$	=	Calcium cynamide
$CaCO_3$	=	Calcium carbonate
$Ca_3(PO_4)_2$	=	Superphosphate
Cc	=	Cubic centimetre (millilitre)
CH	=	Chemara
CH_3COOH	=	Acetic Acid
CIRP	=	Christmas Island Rock Phosphate
CIS	=	Commonwealth of Independent States
Cl	=	Chlorine
Cm^2	=	Square centimetre
Cm^3	=	Cubic centimetre
CO_2	=	Carbon dioxide
$Co(NH_2)_2$	=	Urea
Cr_2O_3	=	Chromium sesquioxide
Cu	=	Copper
$CuSO_4$	=	Copper sulphate
Cv	=	Constant viscosity
Cwt	=	Hundredweight

DOL	=	Division of Labour
DPNR	=	Deproteinised Natural Rubber
DRC	=	Dry rubber content
Eg	=	Example
ENR	=	Epoxidised Natural Rubber
ERP	=	Egyptian Rock Phosphate
Etc	=	Etcetra
EU (EEC)	=	European Union (European Economic Community)
Fe	=	Iron
FELCRA	=	Federal Land Consolidation and Rehabilitation Authority
FELDA	=	Federal Land Development Authority
FRP	=	Florida Rock Phosphate
FTS	=	Freeze-thaw stabilised
GDR	=	German Democratic Republic
GML	=	Ground magnesium limestone
GT	=	Godang Tapen
gtt	=	Grammes per tree per tapping
H	=	Hydrogen
Ha	=	Hectare
HA	=	High ammonia
H3BO3	=	Boric acid
HCHO	=	Formalin
H2O	=	Hydrogen oxide
HNS	=	Hydroxylamine neutral sulphate
IBA	=	Indole butyric acid
Imp	=	Imperial
IRHD	=	International Rubber Hardness Denteometer
IRQPC	=	International Rubber Quality and Packing Conference
IRRDB	=	International Rubber Research and Development Board
IRSG	=	International Rubber Study Group
ISO	=	International Organisation for Standardisation

JRP	=	Jordanian Rock Phosphate
KCl	=	Potassium chloride (Muriate of potash)
Kg	=	Kilogramme
Km	=	Kilometre
Km2	=	Square kilometre
KMPH/kmph	=	Kilometres per hour
K2O	=	Potassium monoxide
K2SO4	=	Potassium magnesium sulphate
LA	=	Low ammonia
LCV	=	Low constant viscosity
Lit	=	Litre
M	=	Metre
O3	=	Ozone
OENR	=	Oil Extended Natural Rubber
OS	=	Ortet selection
P	=	Phosphorus
PA	=	Processing aid
PB	=	Prang Besar
PBIG/GG	=	Prang Besar Isolation Garden/Gough Garden
PC	=	Promotional clone
PCNB	=	Pentachloronitrobe
pH	=	Potential of hydrogen
PHR/phr	=	Parts per hundred of rubber
PM	=	Padang Meiha
PNG	=	Papua New Guinea
Po	=	Initial plasticity
P2O5	=	Phosphorus pentoxide
PPM/rpm	=	Part per million
PR	=	Proefstation voor Rubber
PRC	=	Peoples Republic of China
PRI	=	Plasticity retention index

PVC	=	Polyvinyl chloride
RHC	=	Rubber hydrocarbon
RISDA	=	Rubber Industry Smallholders' Development Authority
RM	=	Ringgit Malaysia
RPM	=	Revolution per minute
RRIC	=	Rubber Research Institute of Ceylon(Sri lanka)
RRII	=	Rubber Research Institute of India
RRIM	=	Rubber Research Institute of Malaysia
RSS	=	Ribbed smoked sheet
SMR	=	Standard Malaysian Rubber
SP	=	Superior or special processing
SPP	=	Sodium pentachlorophenate
TMTD	=	Tetramethyl-thiuram disulphide
US	=	United States (of America)
USA	=	United States of America
USS	=	Unsmoked sheet
V	=	Volume
Vr	=	Viscosity of raw rubber
V/v	=	Volume over volume
W/v	=	Weight over volume
W/w	=	Weight over weight
ZDC	=	Zinc diethyldithiocarbamate
Zn	=	Zinc

MEASUREMENTS

Weight

10 milligrammes	=	1 centigramme
10 centigramme	=	1 decigramme
10 decigrammes	=	1 gramme
10 grammes	=	1 decagramme
10 decagrammes	=	1 hectogramme
10 hectogrammes	=	1 kilogramme
1000 kilogrammes	=	1 tonne
10 quintals	=	1 tonne

Length

10 millimetres	=	1 centimetre
10 centimetres	=	1 decimetre
10 decimetres	=	1 metre
10 metres	=	1 decametre
10 decametres	=	1 hectometre
10 hectometres	=	1 kilometre
10 kilometres	=	1 myriametre

Volume

10 millilitres	=	1 centilitre
10 centilitres	=	1 decilitre
10 decilitres	=	1 litre
10 litres	=	1 decalitre
10 decalitres	=	1 hectolitre
10 hectolitres	=	1 kilolitre

Area

100 square millimetres	=	1 square centimetre
100 square centimetres	=	1 square decimetre
100 square decimetres	=	1 square metre
100 square metres	=	1 square decametre
100 square decametres	=	1 square hectometre

100 square hectometres	=	1 square kilometre
100 square kilometres	=	1 square myriametre
100 centiares	=	1 are
100 ares	=	1 hectare
100 hectares	=	1 square kilometre
10000 square metres	=	1 hectre

General and Approximates

1 litre of water @ 30 °C	=	996.2145 grammes
	=	0.001 cubic metre
1 cubic metre of water @ 30 °C	=	996.2145 kilogrammes
	=	1000 litres
1 cubic metre of salt water	=	1014.3597 kilogrammes
	=	1000 litres
1 cubic metre of clay soil	=	1996.7712 kilogrammes
1 cubic metre of loose soil	=	1517.5461 kilogrammes
1 cubic metre of river sand	=	1273.9388 kilogrammes
1 tea spoon of liquid	=	3.5525 cubic centimetres (millilitres)
1 dessert spoon of liquid	=	7.105 cubic centimetres (millilitres)
1 table spoon of liquid	=	14.21 cubic centimetres (millilitres)
1 condensed milk tin of liquid	=	284.21 cubic centimetres
1 condensed milk tin of mixture, compound and dust fertilisers	=	340.194 grammes
1 condensed milk tin of dalapon and light chemical powders	=	284.21 cubic centimetres
1 condensed milk tin of sodium chlorate	=	284.21 cubic centimetres
1 kerosene tin of liquid	=	20 litres

Conversion from Metric to Conventional System

Centimetre	=	0.3937 inch
Centimetre	=	0.0328048 foot
Metre	=	39.3701 inches
Metre	=	3.28084 feet
Metre	=	1.09361 yards
Metre	=	0.0497097 chain
Kilometre	=	0.621371 mile
Gramme	=	0.035274 ounce
Gramme	=	0.0264554 tahil

Kilogramme	=	2.20462 pounds
Kilogramme	=	1.653466 katis
Kilogramme	=	0.0196841 hundredweight (Imp)
Tonne	=	2204.62 pounds
Tonne	=	19.6841 hundredweights (Imp)
Tonne	=	22.0473 hundredweights (Us)
Tonne	=	16.5347 pikuls
Tonne	=	1.10231 tons (US)
Tonne	=	0.984203 ton (Imp)
Square centimetre	=	0.155 square inch
Square centimetre	=	0.0010764 square foot
Square metre	=	1549.907 square inches
Square metre	=	10.7639 square feet
Square metre	=	1.19599 square yards
Square metre	=	0.002471 square chain
Square kilometre	=	0.386102 square mile
Hectare	=	2.47105 acres
Cubic centimetre	=	0.0610236 cubic inch
Cubic centimetre	=	0.00017598 pint(Imp)
Cubic centimetre	=	0.035315 fluid ounce
Cubic metre	=	1.30795 cubic yards
Cubic metre	=	219.969 gallons(Imp)
Litre	=	0.035315 cubic foot
Litre	=	1.759752 pints(Imp)
Litre	=	35.19504 fluid ounces
Litre	=	0.219969 gallon(Imp)
Celsius	=	5/9 (x °F-32°)

Conversion from conventional to metric system

Inch	=	2.54 centimetres
Inch	=	0.0254 metre
Foot	=	30.48 centimetre
Foot	=	0.3048 metre
Yard	=	0.9144 metre
Chain	=	20.1168 metre
Mile	=	1609.34 metre
Mile	=	1.60934 kilogrammes
Ounce	=	28.3495 grammes
Tahil	=	37.7994 gram

Kati	=	604.879 grammes
Kati	=	0.0604879 kilogramme
Pound	=	0.45359237 kilogramme
Hundredweight (Imp)	=	50.8023 kilogrammes
Hundredweight (Imp)	=	0.050823 tonne
Hundredweight (US)	=	0.045378 tonne
Pikul	=	60.479 kilogrammes
Pikul	=	0.060479 tonne
Ton (US)	=	0.907185 tonne
Ton (Imp)	=	1.01605 tonnes
Square inch	=	6.4516 square centimetres
Square foot	=	929.03 square centimetres
Square foot	=	0.092903 square metre
Square yard	=	0.836127 square metre
Square chain	=	404.686 square metres
Square mile	=	2.58999 square kilometres
Acre	=	0.404686 hectare
Fluid ounce	=	28.4131 cubic centimetres
Fluid ounce	=	0.0284131 litre
Cubic inch	=	16.3871 cubic centimetres
Pint (Imp)	=	568246 litres
Pint (Imp)	=	0.00454609 cubic metre
Gallon (imp)	=	0.00454609 cubic centimetre
Gallon (Imp)	=	4.54609 litres
Cubic foot	=	28.3168 litres
Cubic yard	=	0.764555 cubic centimetres
Fahrenheit	=	9/5 (x °c)+32°

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