



UNIVERSITI PUTRA MALAYSIA

**A COMPARATIVE STUDY ON THE PERFORMANCE OF Metroxylon sagu
AND Metroxylon rumphil GROWN ON GLEYED MINERAL SOIL
AND ORGANIC SOIL**

KELVIN LIM ENG TIAN

FSMB 1991 3

**A COMPARATIVE STUDY ON THE PERFORMANCE OF *Metroxylon sagu*
AND *Metroxylon rumphii* GROWN ON GLEYED MINERAL SOIL
AND ORGANIC SOIL**

KELVIN LIM ENG TIAN

**Master of Science
Universiti Pertanian Malaysia**

1991



**A COMPARATIVE STUDY ON THE PERFORMANCE OF *Metroxylon sagu*
AND *Metroxylon rumphii* GROWN ON GLEYED MINERAL SOIL
AND ORGANIC SOIL**

By

KELVIN LIM ENG TIAN

**Thesis Submitted in Fulfilment of the Requirements
for the Degree of Master of Science
in the Faculty of Food Science and Biotechnology
Universiti Pertanian Malaysia**

December 1991



ACKNOWLEDGEMENT

I wish to express my sincere gratitude to Dr. Mohd. Nasir Azudin, Deputy Dean, Faculty of Food Science and Biotechnology and Dr. Zaliha C. Alang, Head, Department of Biotechnology, for inspiring me to undertake post-graduate training and for the encouragement and invaluable guidance they have given me under their overall supervision of this research project.

I am also indebted to Prof. M. Flach and Ir. D. L. Schuiling of Wageningen Agricultural University, The Netherlands, Mr. John E. Cecil and Mr. Tie Yiu Liong, Department of Agriculture, Sarawak for their correction, advice and guidance in writing this thesis.

Thanks are also due to Mr. Sim Eng Siong, Mr. Lim Chin Pang and Mrs. Patricia Sim for their help in one way or another leading to this opportunity for post-graduate training.

My present training will not have been accomplished without the support, approval and study leave from the Department of Agriculture, granted by the State Government of Sarawak, Malaysia.

Finally, thanks are due to my beloved wife and son, Elizabeth and Jason, for their patience, support, understanding and encouragement at all time.



TABLE OF CONTENTS

	Page
ACKNOWLEDGEMENT	iii
LIST OF TABLES	ix
LIST OF FIGURES	xii
LIST OF PLATES	xiii
ABSTRACT	xiv
ABSTRAK	xvi
CHAPTER	
1 INTRODUCTION	1
An Overview	1
Objectives of the Study	10
2 LITERATURE REVIEW	11
Botany	11
Taxonomy	17
Harvesting and Starch Yield	19
Soil of the Sago Areas and Frond Nutrient Status	29
Characteristics of Sago Starch	33
3 MATERIALS AND METHODS	38
Location and Soil Types	38
Sampling of Sago Palms	42
Determination of Moisture Content	42
Determination of Starch Content	44
Determination of Starch Yield and Bulk Density	44



	Estimation of Starch Yield from Growth Parameters . . .	46
	Determination of Palm Age	47
	Physico-chemical Characteristics of Sago Starch	48
	Determination of Colour	48
	Determination of Ash Content	48
	Determination of Crude Fibre	48
	Determination of Apparent Amylose	49
	Determination of Starch Viscosity	49
	Determination of Total Starch Value	50
	Frond Sampling	50
4	RESULTS	52
	Growth Parameters and Starch Yields of <u>Metroxylon sagu</u> Grown on Different Soil Types	52
	Mineral Soil	52
	Shallow Peat	56
	Deep Peat	59
	Growth Parameters and Starch Yields of <u>Metroxylon</u> <u>rumphii</u> Grown on Different Soil Types	62
	Mineral Soil	62
	Shallow Peat	64
	Deep Peat	68
	Influence of Soil Types on Growth Parameters and Starch Yields of <u>Metroxylon sagu</u>	70



Influence of Soil Types on Growth Parameters and Starch Yields of <u>Metroxylon rumphii</u>	72
Growth Parameters and Starch Yield Comparison of <u>Metroxylon rumphii</u> Grown on Mineral Soils with <u>Metroxylon sagu</u> Grown on Three Different Soil Types	74
Growth Parameters and Starch Yield Comparison of <u>Metroxylon rumphii</u> Grown on Shallow peat with <u>Metroxylon sagu</u> Grown on Three Different Soil Types	74
Growth Parameters and Starch Yield Comparison of <u>Metroxylon rumphii</u> Grown on Deep Peat with <u>Metroxylon sagu</u> Grown on Three Different Soil Types	77
Age of Palms	77
Longitudinal Distribution of Starch for <u>Metroxylon spp</u> Grown on Different Soil Types.	79
<u>Metroxylon sagu</u> /Mineral Soil	80
<u>Metroxylon sagu</u> /Deep Peat	83
<u>Metroxylon rumphii</u> /Mineral Soil	83
<u>Metroxylon rumphii</u> /Deep Peat	86
Radial Distribution of Starch and Bulk Density of <u>Metroxylon sagu</u> and <u>Metroxylon rumphii</u>	88
Bulk Density Determination by Various Methods	90
Starch Yield Determination	90
Starch Density	93
Starch Yield Prediction Through Growth Parameters	94
Physico-chemical Characteristic of Sago Starch	98



Colour	98
Ash Content	100
Crude Fibre	103
Apparent Amylose	105
Viscosity	105
Total Starch Value	106
Leaf Nutrient Levels Within the Frond	107
Leaf Nutrient Level of <u>Metroxylon sagu</u> Grown on Mineral Soil at Consecutive Growth Stages	113
Leaf Nutrient Level of <u>Metroxylon sagu</u> Grown on Mineral Soil with Frond Age	115
Leaf Nutrient Level of <u>Metroxylon sagu</u> Grown on Deep Peat at Consecutive Growth Stages	115
Leaf Nutrient Level of <u>Metroxylon sagu</u> Grown on Deep Peat with Frond Age	118
Leaf Nutrient Level of <u>Metroxylon sagu</u> Grown on Mineral Soil and Deep Peat	118
Selection of an Index Frond for <u>Metroxylon sagu</u> Grown on Mineral Soil	121
Selection of an Index Frond for <u>Metroxylon sagu</u> Grown on Deep Peat	121
5 DISCUSSION	124
Growth Parameters and Starch Yield of <u>Metroxylon</u> spp.	124
Age of Palm	130
Longitudinal Starch Distribution of <u>Metroxylon</u> spp.	131

Radial Starch Distribution of <i>Metroxylon</i> spp	136
Starch Density Method	138
Starch Yield Prediction Through Growth Parameters . . .	138
Physico-chemical Properties of Sago Starch	139
Colour	139
Ash Content	141
Crude Fibre	142
Apparent Amylose Content	144
Viscosity	146
Total Starch Value	147
Leaf Nutrient Level Within the Frond	149
Selection of Index Frond	150
6 SUMMARY AND CONCLUSION	152
BIBLIOGRAPHY	158
APPENDIX	166
VITA	168



LIST OF TABLES

Table	Page
1	Different Physiological Growth Stages of Sago Palm 21
2	Soils of the Sago Areas 30
3	Properties of the Surface Layer (0–25 cm) of the Main Sago Growing Soils in Mukah and Oya–Dalat Areas 32
4	Physico–chemical Characteristics of Various Starches 35
5	Location and Soil Types of Study Plots 40
6	Starch Yield and Growth Parameters of <u>Metroxylon sagu</u> Grown on Mineral Soil 53
7	Starch Yield and Growth Parameters of <u>Metroxylon sagu</u> Grown on Shallow Peat 57
8	Starch Yield and Growth Parameters of <u>Metroxylon sagu</u> Grown on Deep Peat 60
9	Starch Yield and Growth Parameters of <u>Metroxylon rumphii</u> Grown on Mineral Soil 63
10	Starch Yield and Growth Parameters of <u>Metroxylon rumphii</u> Grown on Shallow Peat 66
11	Starch Yield and Growth Parameters of <u>Metroxylon rumphii</u> Grown on Deep Peat 69
12	Influence of Soil Types on Starch Yields of <u>Metroxylon sagu</u> 71
13	Influence of Soil Types on Starch Yields of <u>Metroxylon rumphii</u> 73
14	Comparison of <u>Metroxylon rumphii</u> Grown on Mineral Soil with <u>Metroxylon sagu</u> Grown on Three Different Soils 75
15	Comparison of <u>Metroxylon rumphii</u> Grown on Shallow Peat with <u>Metroxylon sagu</u> Grown on Three Different Soils 76



Table	Page
16	Comparison of <u>Metroxylon rumphii</u> Grown on Deep Peat with <u>Metroxylon sagu</u> Grown on Three Different Soils 78
17	Estimated Age of <u>Metroxylon</u> spp. at Flowering Stage 79
18	Longitudinal Starch Distribution of <u>Metroxylon sagu</u> and <u>Metroxylon rumphii</u> Grown on Different Soil Types 82
19	Bulk Density (g/cc) of Sago Pith Across the Trunk 89
20	Starch Content (% O.D) of Sago Pith Across the Trunk 89
21	Pith Density (g/cc) as Determined by Different Methods 91
22	Starch Yield (kg) per Log of Sago Trunk Determined by Two Methods 92
23	Starch Content (% O.D) Determined by Two Methods 93
24	Starch Density (g/cc) Determined by Two Methods 94
25	Regression Equation for Starch Yield Prediction of Sago Palms in Mineral Soil 96
26	Regression Equation for Starch Yield Prediction of Sago Palms in Deep Peat 97
27	Colour of Sago Starch of <u>Metroxylon sagu</u> Grown on Mineral Soil and Deep Peat 99
28	Colour of Sago Starch of <u>Metroxylon rumphii</u> Grown on Mineral Soil and Deep Peat 101
29	Physico-chemical Properties of Different Growth Stages of <u>Metroxylon sagu</u> Grown on Different Soil Types 102
30	Physico-chemical Properties of Different Growth Stages of <u>Metroxylon rumphii</u> Grown on Different Soil Types 104
31	Leaf Nutrient Within Frond of <u>Metroxylon sagu</u> at Plawei Stage 108
32	Leaf Nutrient Within Frond of <u>Metroxylon sagu</u> at Plawei Manit Stage 109



Table	Page
33	Leaf Nutrient Within Frond of <u>Metroxylon sagu</u> at Bubul Stage 110
34	Leaf Nutrient Within Frond of <u>Metroxylon sagu</u> at Angau Muda Stage 111
35	Leaf Nutrient Level (%) of <u>Metroxylon sagu</u> 112
36	Leaf nutrient level of <u>Metroxylon sagu</u> Grown on Mineral Soil at Consecutive Growth Stages 114
37	Leaf Nutrient Level of <u>Metroxylon sagu</u> Grown on Mineral Soil with Frond Age 116
38	Leaf Nutrient Level of <u>Metroxylon sagu</u> Grown on Deep Peat at Consecutive Growth Stages 117
39	Leaf Nutrient Level of <u>Metroxylon sagu</u> Grown on Deep Peat with Frond Age 119
40	Leaf Nutrient Concentration (%) of <u>Metroxylon sagu</u> on Mineral Soil and Deep Peat 120
41	The Coefficient of Variation of Nutrient Concentrations in Fronds 3 to 9 of <u>Metroxylon sagu</u> Grown on Mineral Soil 122
42	The Coefficient of Variation of Nutrient Concentrations in Fronds 3 to 9 of <u>Metroxylon sagu</u> Grown on Deep Peat 123



LIST OF FIGURES

Figure		Page
1	Main Sago Producing Areas in Sarawak	2
2	Molecular Structure of Amylose and Amylopectin	34
3	Location of Study Areas	39
4	Sampling of Sago Pith	43
5	Starch Yield of <u>Metroxylon sagu</u> at Different Growth Stages	55
6	Starch Yield of <u>Metroxylon rumphii</u> at Different Growth Stages	65
7	Longitudinal Starch Distribution of <u>Metroxylon sagu</u> with Trunk Height (Mineral soil)	81
8	Longitudinal Starch Distribution of <u>Metroxylon sagu</u> with Trunk Height (Deep peat)	84
9	Longitudinal Starch Distribution of <u>Metroxylon rumphii</u> with Trunk Height (Mineral soil)	85
10	Longitudinal Starch Distribution of <u>Metroxylon rumphii</u> with Trunk Height (Deep peat)	87
11	Trunk Girth vs Trunk Height of <u>Metroxylon sagu</u>	134
12	Trunk Girth vs Trunk Height of <u>Metroxylon rumphii</u>	135



LIST OF PLATES

Plate		Page
1	Smooth Sheathed <u>Metroxylon sagu</u>	5
2	Spiny Sheathed <u>Metroxylon rumphii</u>	6
3	Inflorescence Palm	14
4	Plawei – Palm that has reached maximum vegetative growth	22
5	Plawei Manit – inflorescence emerging palm	23
6	Bubul – inflorescence developing palm	24
7	Angau Muda – flowering palm	25
8	Angau Tua – fruiting palm	26



Abstract of Thesis Submitted to the Senate of
Universiti Pertanian Malaysia in Fulfillment of the
Requirements for the Degree of Master of Science

**A COMPARATIVE STUDY ON THE PERFORMANCE OF
Metroxylon sagu AND Metroxylon rumphii GROWN ON
GLEYED MINERAL SOIL AND ORGANIC SOIL**

By

KELVIN LIM ENG TIAN

December 1991

Supervisor : Mohd Nasir Azudin, Ph.D.

Faculty : Faculty of Food Science and Biotechnology

Sago palm is currently one of the major starch resources in Malaysia, as indicated by the M\$14 million average annual export value obtained in the past few years. The two main types of sago palms found in Sarawak are the smooth sheathed Metroxylon sagu and spiny sheathed Metroxylon rumphii. These are grown all over Sarawak on different soil types ranging from mineral soil, shallow peat and deep peat. To date, no information is available on the performance of these two varieties grown on these soil types. This study was conducted to determine the effect of soil types on the growth, physical characteristics of the palms, the starch quality, and yield of the resultant starch extracted from these palms. The longitudinal and radial starch distribution of the palm, the different methods of estimating starch yields and the leaf nutrient variation of the sago palm were also evaluated.

Results from this study indicated that sago palm performed better on mineral soil than on the marginal peat soil with starch yield ranging from 182 to 260 kg / trunk for Metroxylon sagu in mineral soil compared to 128 to 188 kg / trunk in deep peat. In terms of starch yields against palm maturity, total starch yield was found to increase with palm age up to the 'Angau Muda' (flowering) stage after which the total starch content decreased sharply. The physico-chemical characteristics of the sago starch from both varieties and different stages of maturity did not differ significantly. The longitudinal and radial distribution of the starch in trunk of the palm was uneven. The upper portion of the trunk and the outer segment of the pith had lower starch contents. The starch yield per trunk of sago can be estimated by measuring the trunk length and girth at breast height. Studies showed that estimating of starch yield based on volume basis is easier and more accurate. The study on the variation leaf nutrient content of sago palm recommended frond 9 be sampled for the assessment of the nutrient status of the palm.

Abstrak Tesis Yang Dikemukakan Kepada Senat
Universiti Pertanian Malaysia Sebagai Memenuhi Syarat
Keperluan Untuk Ijazah Master Sains

KAJIAN BANDINGAN PRESTASI Metroxylon sagu DAN Metroxylon rumphii YANG DITANAM DI TANAH LIAT DAN TANAH GAMBUT

Oleh

KELVIN LIM ENG TIAN

Disember 1991

Penyelia : Mohd Nasir Azudin, Ph.D.
Fakulti : Fakulti Sains Makanan dan Bioteknologi

Palma sagu kini merupakan salah satu daripada sumber kanji yang utama di Malaysia, seperti yang ditunjukkan oleh nilai eksport sebanyak M\$ 14 juta beberapa tahun kebelakangan ini. Dua jenis palma sagu utama di Sarawak adalah Metroxylon sagu yang licin dan Metroxylon rumphii yang berduri. Palma ini boleh didapati dalam berbagai jenis tanah, daripada tanah liat (mineral soil), tanah gambut cetek (shallow peat) dan tanah gambut dalam (deep peat) di merata-rata tempat di Sarawak. Sehingga kini, tidak ada maklumat mengenai prestasi kedua-dua varieti palma ini dalam jenis-jenis tanah tersebut. Kajian ini telah dijalankan untuk menentukan kesan jenis-jenis tanah ke atas pertumbuhan, sifat-sifat fizikal palma tersebut, mutu kanji dan hasil kanji yang diekstrak daripada palma-palma tersebut. Taburan kanji di dalam batang palma secara memanjang dan membulat, kaedah-kaedah

berlainan untuk menjangka hasil kanji dan variasi nutrien daun palma sagu tersebut juga dikaji.

Keputusan daripada kajian ini menunjukkan bahawa palma sagu memberi prestasi yang lebih baik di atas tanah mineral daripada tanah gambut dalam dengan hasil kanji sebanyak 182 – 260 kg/ batang pokok Metroxyon sagu di atas tanah liat berbanding dengan hasil sebanyak 128 – 188 kg/batang pokok di atas tanah gambut dalam. Dari segi hasil kanji melawan kematangan palma, jumlah hasil kanji didapati bertambah dengan pertambahan umur palma sehingga peringkat "Angau Muda" di mana selepas itu jumlah kandungan kanji menurun dengan mendadak. Sifat-sifat fiziko-kimia kanji sagu daripada kedua-dua varieti tersebut dan daripada kumpulan umur yang berbeza tidak menunjukkan perbezaan yang bererti. Taburan kanji palma secara memanjang dan membulat tidak sekata. Bahagian atas dan segmen luar empular mempunyai kandungan kanji yang lebih rendah. Hasil kanji sebatang pokok sagu boleh dijangkakan dengan mengukur panjang batang pokok dan ukurlilit pada paras dada. Kajian ini menunjukkan bahawa jangkaan hasil kanji yang berasaskan dasar isipadu adalah lebih mudah dan tepat. Kajian ke atas variasi nutrien daun palma sagu mencadangkan bahawa daun ke 9 digunakan untuk penilaian taraf nutrien palma tersebut.

**Dedicated to my beloved wife and son,
Elizabeth Wong and Jason Lim**



CHAPTER 1

INTRODUCTION

An Overview

Malaysia, in particular the State of Sarawak, is the world leader in the field of sago starch production and sago research. Sago holdings have been known to exist in Sarawak for 400 years or more. Known locally as "rumbia" or "balau" in Melanau, the sago palm (Metroxylon spp.) is found in the vast areas of contiguous equatorial peat swamp of Sarawak. Grown under semi-wild conditions, it has a special niche in this marginal land resource and provides a livelihood for many of the inhabitants associated with this resource. Figure 1 shows the major sago producing areas in Sarawak. An informal survey by Wee (1977) indicated that at least 84 villages, comprising some 6,000 households with a population of 40,000 were working or dependent on commercial sago exploitation. Among agricultural products, sago starch currently ranks as the State's fifth highest revenue-earner after pepper, rubber, oil palm and cocoa. Sarawak exports about 30,000 tonnes of sago starch annually earning about M\$14 million (US\$ 5,263,158) in 1988 (Azudin and Lim, 1990).

To sustain and further develop the sago starch industry, the Sarawak government has made a commitment to promote the industry in the state.



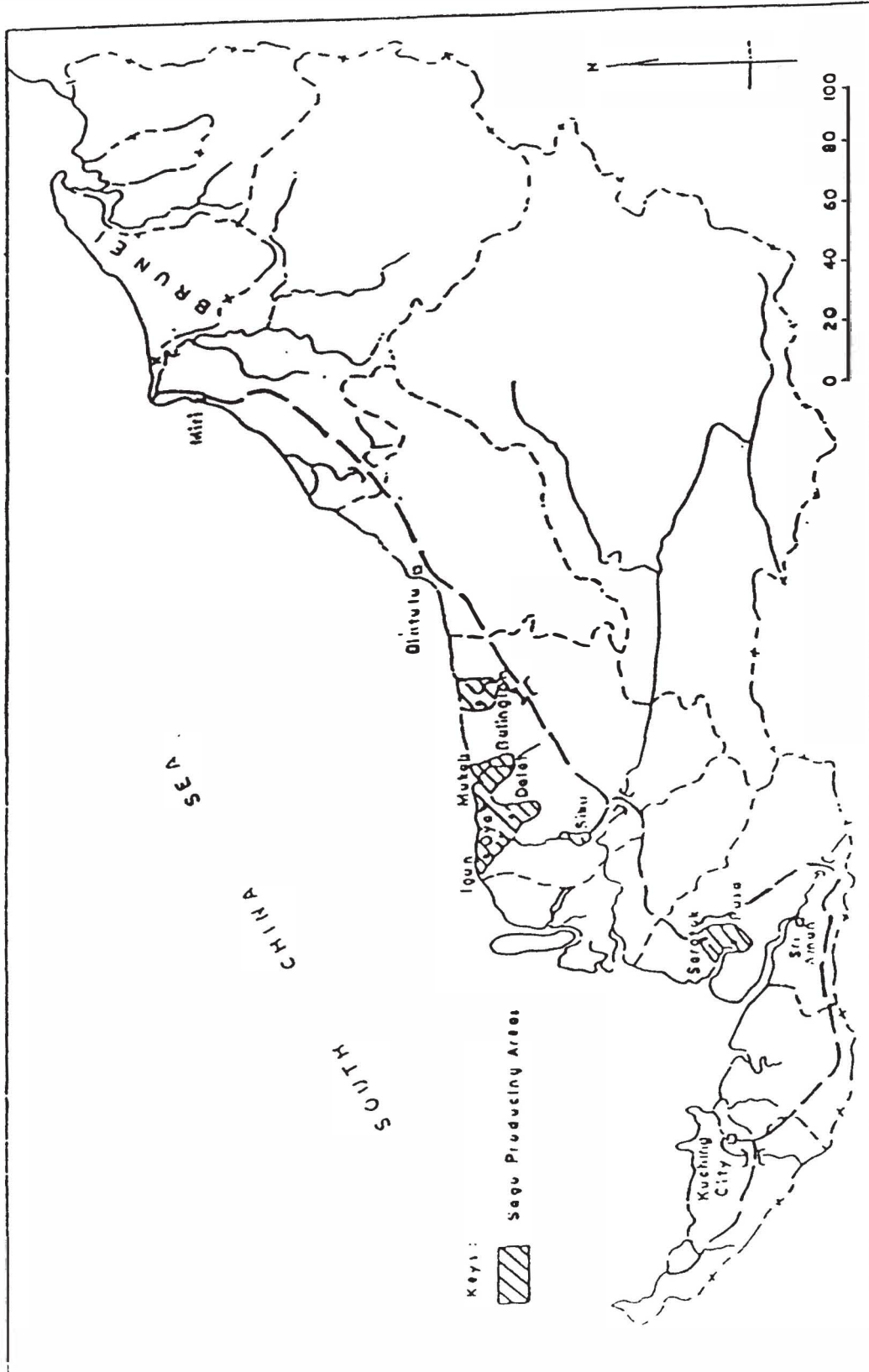


Fig. 1
Main Sago Producing Areas In Sarawak

Through her local agencies (Sarawak Economic and Development Corporation, Land Custody and Development Authority) and the Department of Agriculture, research has been intensified and various projects implemented to fulfil this commitment. In 1982, a Sago Research Station was established by the Department of Agriculture in Dalat, Sibuh covering an area of 204 ha. A Sago Research Laboratory was also set up to carry out research on various aspects of sago processing, starch quality improvement and sago starch utilization. In 1987, the Sarawak government set up a 10 million dollar modern sago factory in Mukah through the Sarawak Economic Development Corporation (SEDC) to produce high quality refined sago starch. A sago plantation was also established by the Land Custody and Development Authority (LCDA) near Mukah. Under this project, approximately 2,278 ha are currently being developed and a total of 16,188 ha (40,000 ac) is planned for development within the ten-year period (1987–1997) (Kueh *et al.*, 1987). In the past few years a number of privately owned modern multimillion dollar sago factories have also been set up in Dalat, Mukah and Sibuh, producing high quality sago starch for export. All these developments have increased the demand for sago logs. This will not only encourage more farmers to rehabilitate their sago groves but also to extend their plantings.

Research work on sago, in general, is scarce, despite the versatile usefulness of the commodity. Most of the sago research in Sarawak is carried out by the Department of Agriculture and the focus is currently toward the improvement of crop production through agronomic trials, botanical, and soil studies, as well as pest and disease control. Only very recently has research begun in earnest on the characteristics of the sago starch, its chemical modification and uses in the food industry (Azudin, 1990). To date, most of the studies on the performance of sago palm in Sarawak have centred on Metroxylon sagu, (Plate 1) the smooth sheathed variety. Perusal of the literature reveals little information on the performance and starch yield of Metroxylon rumphii, (Plate 2) the spiny sheathed variety. The lack of this information gives rise to conflicting opinions on the performance of these two varieties. Sago farmers in the Mukah and Dalat areas in the Sibu Division of Sarawak believe that Metroxylon rumphii produces less starch per trunk than Metroxylon sagu. However, sago farmers in the Balingian, Pusa and Saribas areas claim otherwise. Most factory owners in Mukah and Dalat therefore prefer to purchase Metroxylon sagu due to its purportedly greater starch content. This uncertainty has caused a great discrepancy in the price of sago logs from these two varieties. At present Metroxylon sagu can cost as high as



Plate 1. Smooth sheathed Metroxylon sagu (ROTTB.)



Plate 2. Spiny sheathed Metroxylon rumphii (MART.)