UNIVERSITI PUTRA MALAYSIA

CELLULAR STRUCTURE OF STEMS AND FRONDS OF 14 AND 25 YEAR-OLD ELAEIS GUINEENSIS JACQ.

SHIRLEY @ MARYLINDA BAKANSING

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By

SHIRLEY @ MARYLINDA BAKANSING

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of Requirement for the Degree of Master of Science

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To both my beloved parents
Abel Bakansing & Lucy Andui Masery

My sister and brothers
Sylvia, Sylvester, Sylvianus, Sylverinus and Sixtus

My beloved husband
Boyd Sun Fatt

And also to
Universiti Malaysia Sabah

&

Intensification Research on Priority Areas (IRPA),
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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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Chairman: Prof. Mohd. Hamami Sahri, Ph.D.

Faculty: Forestry

Oil palm (*Elaeis guineensis* Jacq.) is one of the most important commercial crops in Malaysia. It has been cultivated in Malaysia mainly for palm oil and related products. The mature trees are felled at the end of its economic life (25 years). The stem which is rich in lignocellulosic material is an abundant supply for wood-based industry. However, oil palm which is a monocotyledoneous species behaves unlike ordinary wood. Therefore, this study aimed to i) analyse the detail cellular structure of oil palm stem and frond; ii) evaluate the fibre morphology oil palm at different age groups and height levels; and iii) analyse the structure of the oil palm stem, and its relation to its physical properties.

In this study, 3 trees each of 14 and 25 year-old oil palm were selected. The samples were obtained from FELDA Keratong, Pahang. Three discs of 15 cm thick were taken from bottom, middle and top levels of each stem. Smaller block samples were taken from outer, middle and inner zone of each disc. Different sizes of blocks were prepared for microscopic structure study, fibre morphology test, determination of number of vascular bundles, moisture content test and density test. Frond samples

were also taken from bottom, middle and level of oil palm crown for microscopic structure study.

This study showed that *E. guineensis* stem consisted of two distinct structures: vascular bundles and ground parenchyma cells. The ground parenchyma cells embedded the vascular bundles. Vascular bundles were congested at the outer and gradually reduced in number toward the central part of the stem, with the range of 42-190/cm^2 in 14 year-old stem and 51-184/cm^2 in 25 year-old stem. Whereas, the amount of ground parenchyma cells increased toward the central part of the stem. The vascular bundles generally contained vessels (metaxylem), fibrous sheath, phloem, protoxylems, silica and parenchyma. Fibres of oil palm were irregular in length, diameter, cell wall thickness and number of wall layers, from outer to inner zone and from bottom to top level. In the 14 year-old stem, the means of fibre length ranged 1197-1864 μm and 1047-1545 μm in 25 year-old stem. Means of fibre diameter of 14 year-old stem were 35.71-42.47 μm and 26.83-35.35 μm in 25 year-old stem. Means of fibre cell wall thickness were 4.70-6.32 μm in 14 year-old stem and 5.37-9.66 μm in 25 year-old stem. There were 1-3 layers of wall in 14 year-old stem and 1-6 layers of wall in 25 year-old stem.

The basic density values were 106-199 kg/m^3 in 14 year-old stem and 144-536 kg/m^3 in 25 year-old stem. Moisture content was 421-839% in 14 year-old stem and 82-458% in 25 year-old stem. It was found that the oil palm wood density was highest at outer zone which contained highest number of vascular bundles, several layers of fibre wall and small amount of parenchyma cells. Whereas, moisture content was the

lowest at outer zone which contained the highest number of vascular bundles and small amount of parenchyma cells.

The internal structure of oil palm frond is generally similar to the oil palm stem, however differences are found in vascular bundles, fibrous sheath and cell wall structure. The vascular bundles are congested at the outer zone of the petiole and scattered at the centre of petiole. The vascular bundles are in elongated shape at the outer zone; and there are in round shape at the centre and tip of the petiole. The vascular bundles consist of fibrous sheaths, vessel elements, phloem, parenchyma and stegmata. Vascular bundles of frond composed of two fibrous sheaths or fibre caps located at both sides. Fibre wall of frond is formed of two layers of wall. The wall layers are irregular in thickness at different locations. Fibre length of 14 year-old frond was ranged from 1225 µm to 1293 µm, whereas, the 25 year-old was ranged from 1267 µm to 1640 µm. The fibre of 14 year-old was ranged from 18.73 µm to 33.49 µm in diameter, whereas, the 25 year-old was ranged from 19.80 µm to 52.74 µm. The fibre wall thickness of 14 year-old was ranged from 3.91 µm to 11.43 µm, whereas, the 25 year-old was ranged from 4.01 µm to 19.89 µm.

Therefore, the study can conclude that the two different age groups of oil palm did show variations in terms of fibre length, diameter and fibre wall thickness. It is also found that the vascular bundles structure and wall layers illustrate differences between the stem and frond.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk Ijazah Master Sains

STRUKTUR SEL BATANG DAN PELEPAH 14 DAN 25 TAHUN *ELAEIS GUINEENSIS* JACQ.

Oleh

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Kelapa sawit (*Elaeis guineensis* Jacq.) adalah salah satu daripada tanaman komersial yang penting di Malaysia. Ia ditanam di Malaysia untuk menghasilkan minyak kelapa sawit. Pokok kelapa sawit yang matang ditebang selepas hayat ekonominya (25 tahun) tamat. Batang kelapa sawit yang kaya dengan bahan lignoselulosa adalah sumber bahan mentah kepada industri berasaskan kayu. Walaubagaimanapun, kelapa sawit daripada jenis monokotiledon mempunyai ciri-ciri yang berbeza dengan kayu biasa. Oleh itu, kajian ini bertujuan untuk 1) menganalisa struktur batang dan kelapa sawit secara terperinci; ii) menilai morfologi gentian pada kumpulan umur dan paras ketinggian yang berbeza; dan iii) menganalisa struktur batang kelapa sawit dan hubungannya dengan ciri-ciri fizikal.

Di dalam kajian ini, 3 pokok berumur 14 dan 25 tahun telah dipilih. Sampel telah diperolehi dari FELDA Keratong, Pahang. Tiga ceper dengan ketebalan 15 cm dipotong daripada paras pangkal, tengah dan atas batang kelapa sawit. Blok bersaiz kecil disediakan daripada zon luar, tengah dan dalam ceper. Blok-blok sampel berlainan saiz disediakan untuk kajian struktur mikroskopik, ujian morfologi gentian,

penentuan bilangan berkas vaskular, ujian kandungan lembapan, ujian ketumpatan dan ujian pengecutan. Sampel pelepah juga diambil daripada pelepah paras bawah, tengah dan atas silara kelapa sawit untuk kajian struktur mikroskopik.

Kajian menunjukkan batang *E. guineensis* mempunyai dua struktur yang ketara: berkas vaskular dan sel-sel parenkima. Tisu parenkima mengeliligi berkas vaskular. Berkas vaskular adalah padat di bahagian tepi dan bilangannya semakin berkurangan dari zon tepi ke arah pusat batang, dengan julat 42-190/cm^2 bagi batang 14 tahun dan 51-184/cm^2 bagi batang 25 tahun. Manakala jumlah sel parenkima bertambah dari bahagian luar ke arah dalam batang. Amnya, berkas vaskular mengandungi vesel (metaxilem), berkas gentian, floem, protoxilem, silika dan parenkima. Saiz gentian tidak seragam dari segi panjang, diameter, ketebalan dinding sel dan bilangan lapisan dinding sel, dari zon tepi ke empulur. Pada batang 14 tahun, min panjang gentian ialah 1197-1864 µm dan 1047-1545 µm bagi 25 tahun. Min diameter gentian bagi pokok muda ialah 35.71-42.47 µm dan 26.83-35.35 µm bagi pokok tua. Min ketebalan dinding sel ialah 4.70-6.32 µm bagi batang 14 tahun dan 5.37-9.66 µm bagi 25 tahun. Terdapat 1-3 lapisan dinding sel di dalam gentiang batang 14 tahun dan 1-6 lapisan dinding sel gentian di dalam batang 25 tahun. Min ketumpatan asas kayu ialah 106-199 kg/m^3 bagi batang 14 tahun dan 144-536 kg/m^3 bagi batang 25 tahun. Min kandungan lembapan ialah 421-839% di dalam batang 14 tahun dan 82-457% di dalam batang 25 tahun. Didapati bahawa ketumpatan adalah tinggi pada zon tepi yang mengandungi bilangan berkas vaskular yang banyak, beberapa lapisan dinding sel, dengan jumlah sel parenkima yang rendah. Manakala, kandungan lembapan adalah rendah di zon tepi yang mempunyai bilangan berkas vaskular yang tinggi dengan jumlah sel parenkima yang rendah.

Struktur dalaman pelepah kelapa sawit adalah hampir sama dengan struktur batang, namun demikian, terdapat perbezaan pada struktur berkas vaskular, berkas gentian dan dinding sel gentian. Berkas vaskular adalah padat di bahagian tepi petiol dan berselerak di bahagian dalam petiol. Berkas vaskular berbentuk bujur di bahagian tepi; dan berbentuk bulat di bahagian dalam dan hujung tepi petiol. Berkas vaskular mengandungi berkas gentian, elemen vesel, floem, parenkima dan stegmata. Berkas vaskular mempunyai dua berkas gentian terletak di kedua-dua belah. Dinding sel terdiri daripada dua lapisan dinding. Ketebalan dinding sel adalah tidak sama di bahagian yang berlainan. Panjang gentian bagi petiol pelepah 14 tahun ialah di antara 1225 µm hingga 1293 µm, manakala bagi 25 tahun ialah di antara 1267 µm hingga 1640 µm. Diameter gentian bagi petiol pelepah 14 tahun ialah di antara 18.73 µm hingga 33.49 µm, manakala, bagi 25 tahun ialah di antara 19.80 µm hingga 52.74 µm. Ketebalan dinding sel bagi petiol pelepah 14 tahun ialah di antara 3.91 µm hingga 11.43 µm, manakala, bagi 25 tahun ialah di antara 4.01 µm dan 19.89 µm.

Oleh itu, kajian ini menyimpulkan bahawa umur kelapa sawit yang berbeza menunjukkan variasi dari segi panjang gentian, diameter dan ketebalan dinding gentian. Kajian ini juga mendapati bahawa terdapat perbezaan struktur berkas vaskular dan lapisan dinding sel di antara batang dan pelepah.

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