ESTIMATING TREE CROWN MODEL WITH MULTIPLE REGRESSION

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DECLARATION

I declare that this dissertation is the result of my own independent works, except where otherwise stated.

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ABSTRACT

Tree crown is solely responsible for the process of photosynthesis where it changes carbon dioxide to oxygen. Without these trees, our world will be full with carbon dioxide so trees are important in balancing the oxygen cycle. In this dissertation, we would like to estimate the volumetric crown biomass of *Cinnamomum iners* a tropical species. So 55 trees were taken as samples for this research where data of the height of tree, crown projected area and crown base height were taken to calculate the crown volume. All the data were taken from the cinnamomum trees in University Malaysia Sabah (UMS). The main objective is to find the best model using multiple regression (MR) where the equation can represent the growth of the crown. When doing the multiple regression, we would like to see whether the variable like crown length (in diameter), diameter at breast height (DBH), tree height, height of first branch and distance the nearest tree would affect the growth of the crown. It was found that these variables can give positive and negative effects to the crown volume. Besides that, this dissertation would also like to determine the maximum and minimum value of the crown volume so we can know to the optimum length of the crown radius a tree can grow.

ABSTRAK

"Crown" pokok ialah bahagian yang menghasilkan fotosinthesis dimana ia menukar karbon dioksida kepada oksigen. Jikalau tanpa pokok tersebut, dunia ini akan dipenuhi dengan karbon dioksida, jadi pokok penting dalam mengimbangi dunia ini. Dalam disertasi ini, ini adalah untuk perkiraan "volumetric crown biomass" bagi *cinnamomum iners* sejenis species tropika. 55 batang pokok telah diambil sebagai sampel dalam kajian ini dimana data untuk ketinggian pokok, luas "projected crown" dan ketinggian dahan pokok diambil untuk mengukur isipadu "crown". Segala data yang diambil adalah dari pokok cinnamomum yang ditanam di University Malaysia Sabah(UMS). Objektif utama adalah dengan menggunakan "Multiple Regression" (MR) untuk mencari model terbaik dimana persamaan itu boleh mewakili pertumbuhan "crown". Semasa melakukan "multiple regression" pembolehubah seperti panjang "crown"(dalam diameter), "diameter at breast height" (DBH), ketinggian pokok, tinggi hingga dahan pertama, dan jarak untuk pokok terdekat akan diambil kira untuk mengetahui samada ia memberi kesan pertumbuhan untuk "crown". Jadi dari kajian ini, adalah didapati bahawa ada pembolehubah yang memberi kesan positif dan negatif. Selain itu, desertasi ini juga ingin menentukan nilai minimum dan maksimum isipadu "crown" untuk mengetahui sebesar manakah pertumbuhan sesebuah pokok itu.

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MR	Multiple Regression
cm	centimetre
mm	milimetre
m	metre
^{o}C	Celsius
%	percent
DBH	Diameter at Breast Height
^{o}	degree
θ	angle degree
tan	tangent
CV	crown volume
TH	tree height
CBH	estimated covered base height
CG	estimated covered grown
t	t-distribution
$\bar{X}$	estimated mean
μ	mean
S	standard deviation
n	number of observations
d.f	degree of freedom
σ^2	variance
ESS	sum of square error
k	number of parameters estimated
ESS_R	sum of square error for restricted model
ESS_U	sum of square error for unrestricted model
Σ	summation
UMS	Universiti Malaysia Sabah

CHAPTER 1

INTRODUCTION

1.1 HISTORY OF CINNAMOMUM

Cinnamomum actually is derived from the Greek root kinnamon or kinnamomon, which bring the meaning of sweet wood. Just like in Malaysia, we call it kayu manis. Cinnamon and cassia are among the earliest known species used by humans. The genus cinnamomum belongs to the family of Lauraceae (Lee, 2003). It is native to Sri Lanka where it is grown on a large scale and exported. There are many kinds of cinnamomum in the world while only in Peninsular Malaysia, there consists of 21 species of cinnamomum (Ibrahim & Goh, 1992).

The early history of cinnamon and cassia is very interesting. They are among the earliest spices of herbs used. They formed the ingredients of the embalming mixture in ancient Egypt, and were among the most expensive materials in ancient Greece and Rome where only the royalty could afford them. It was imported to Egypt from China as early as 2000 BC, and is mentioned in the Bible

" The Lord spake unto Moses. Thou also unto thee principal spices, of pure myrrah five hundred shekels, and of sweet cinnamon half so much...and of cassia five hundred shekels.....And thou shalt make of it an oil holy anointment. And thou shalt anoint the tabernacle of the congregation therewith and the ark of testimony"

Old Testament of the Bible (Exodus 30:23-26)

It is also had been mentioned by Herodotus and other classical writers. It was commonly used on funeral pyres in Rome, and the Emperor Nero is said to have burned a year's supply of cinnamon at the funeral for his wife Poppaea Sabina, in 65 AD.

In the Middle Ages, the sources of cinnamon was a mystery to the Western world. Arab traders brought the spice by overland trade routes to Alexandria in Egypt, where it was bought by Venetian traders from Italy who held a monopoly on the spice trade in Europe. The disruption of this trade by the rise of other Mediterranean powers such as the Mameluks Sultans and the Ottoman Empire was one of many factors that led Europeans to search more widely for other routes to Asia.

This had make the Portuguese traders finally find Ceylon (Sri Lanka). The Portuguese established a fort on the island in 1518, and protected their own monopoly for over a hundred years. In 1638, Dutch traders dislodged the Portuguese by allying with the inland Ceylon kingdom of Kandy. The Dutch East India Company continued to overhaul the methods of harvesting in the wild and eventually began to cultivate its own trees.

The British took control of the island from the Dutch in 1796. However, the importance of the monopoly of Ceylon was already declining, as cultivation of the cinnamon tree spread to other areas, the more common cassia bark became more acceptable to consumers, and coffee, tea, sugar and chocolate began to outstrip the popularity of traditional spices.

Today, cinnamon is grown mainly in Sri Lanka, whilst minor producing countries include Seychelles and Madagascar. It also naturally found in southern India and Tenasserim Hills of Myanmar (De Guzman & Siemonsma, 1999). Sri Lanka produces the largest and the best quality of cinnamon bark, mainly as quills. The official statistics available from FAO (FAOSTAT) the world production of cinnamon during 2000 was 90,213 from an area of approximately 132,970 ha (FAO, 2000). In Sri Lanka, it is estimated to be around 24,000 ha and 3400ha in the Seychelles producing respectively around 12,000 and 600 t (Coppen, 1995). Cinnamon leaf oil mostly produced in these countries, though the bark oil is distilled mostly in the importing countries. Sri Lanka export is to be around 120 t of leaf oil and 4-5 t of bark oil. Cinnamaldehyde is the major component of bark and leaf oil. Cinnamon bark oil is a very high value oil but there is no international standard for cinnamon bark oil. The price of the oil will be determined by the cinnamaldehyde content where the higher the cinnamaldehyde, the higher would be the price.

1.2 CINNAMOMUM CHARACTERISTICS

Cinnamomum is a small evergreen tree. In the botany description about evergreen is that the plant will retains it leaves all around the year. The economic life span of a cinnamon plant is around 30-40 years. Dasanayake *et al.* (1995) publication has given the main identifying characters of cinnamomum as (i) the length of the two basal or sub-basal ascendant veins; (ii) the indumentums (covering of hairs); and (iii) the thalamus cup under the fruits. The number of anther cells of the third whorl of stamens was also considered to be a useful character. The following taxanomical description is adapted from Dasanayake *et al.* (1995);

"they said that the cinnamon tree is a moderately sized tree which will grow up to 16 m tall. It diameter will grow until 60 cm diameter at breast height. The bark of cinnamon is light pinkish brown in colour. It will grow up to 10 mm thick with a strong pleasant cinnamon smell. Meanwhile the shape of cinnamon leaf is oval or elliptic which is around 3 X 7 - 8 X 25cm."

The following photo 1.1 and 1.2 shows the cinnamomum iners leaf where photo 1.1 is the mature leaf and photo 1.2 is the young leaf. Photo 1.3 is the fruits of the cinnamomum while the last photo 1.4 is the whole tree of the cinnamomum iners.

Photo 1.1

Photo 1.2

Photo 1.3

Photo 1.4

1.3 HARVESTING CINNAMOMUM

In around two to three years after planting the cinnamon plants reach a height of 1.5 – 2 m. Generally cinnamon can be harvested two to three times per year depending on the rainfall and soil fertility. After harvesting the tree will be coppicing where the next year dozen or so shoots will form from the roots. Coppicing is a traditional method of woodland management in which young tree stems are cut down to a low level. These shoots are then stripped of their bark which is left to dry. Only the thin 0.5mm inner bark is used while the outer woody portion is removed leaving metre long cinnamon strips that curl into rolls on drying. These rolls are then cut to 5-10 cm long pieces for sale. The most valuable products are obtained from the bark of the cinnamon tree (Agarwall, 1997). The figure 1.1 below show the flow of processing cinnamomum.

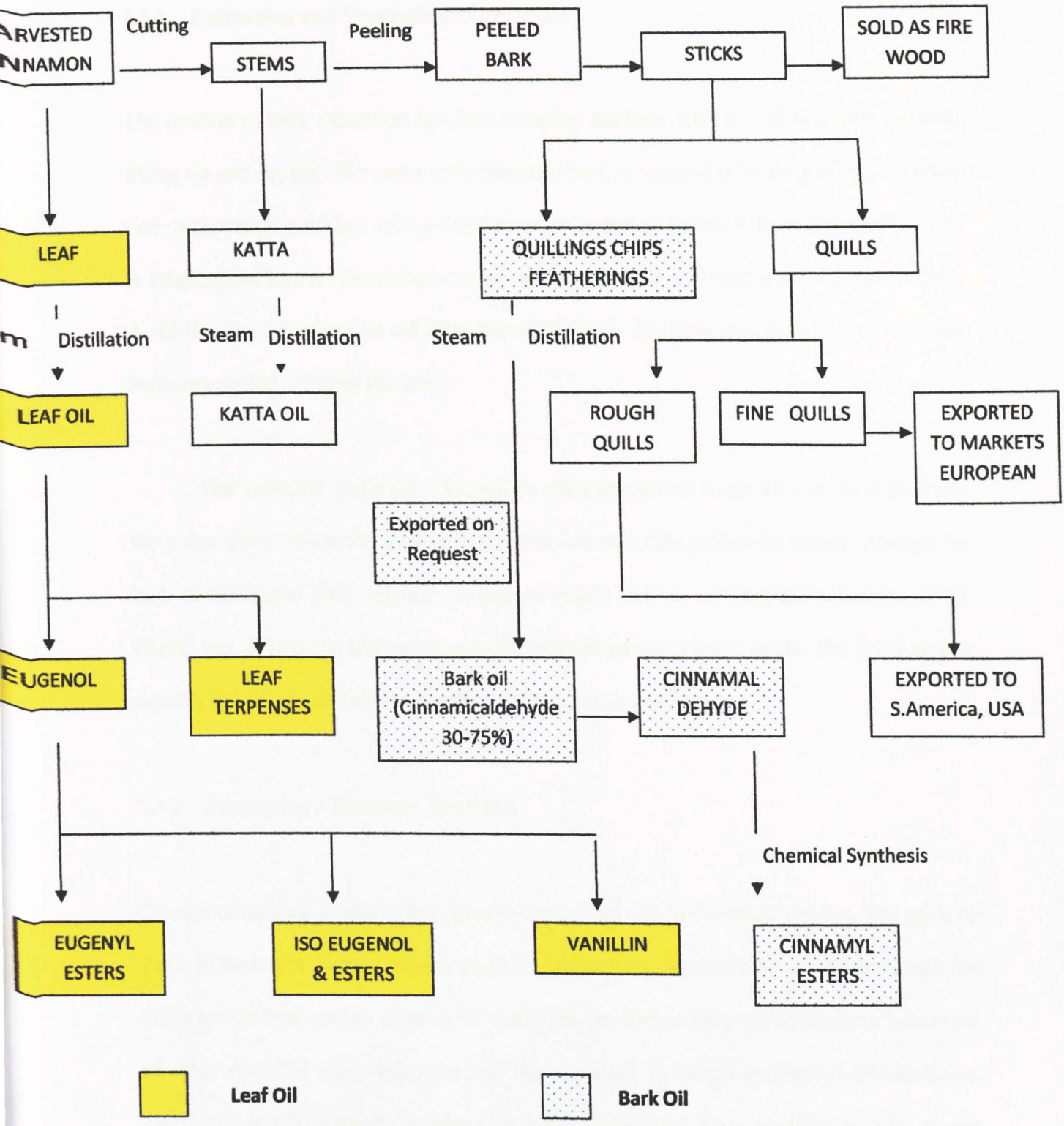

Figure 1.1 Processing cinnamomum

1.3.1 Extraction and Processing of the Bark

The process of bark extraction involves scraping the bark with a steel scrapper, peeling, filling up and drying. The outer cork from the bark is scraped prior to peeling. Then the bark is thoroughly rubbed with a wooden or brass rod to loosen it from the woody stem. A longitudinal line is then drawn on the bark from end to end with a sharp pointed knife. A similar line is drawn on the opposite of the bark. By then, two equal halves of long barks are peeled off from the stick.

The prepared quills are arranged in rows suspended by ropes and dried in shade for a few days. When the bark dried, it will become pale yellow in colour. Always the bark is fumigated with sulphur dioxide to obtain yellow colour (Bhatacharjee, 1998). Beside that, it also can kill any insects and microorganisms in the quills. The dried bark is actually quiet hard and can be handled without much breakage.

1.3.2 Processing Cinnamon Bark Oil

Cinnamon bark oil is one of the expensive essential oils in the world market. The price or value of bark oils, largely depend on the material used to distill the oil. Even though the quills are the best quality of bark oil, quills are not always used for distillation. Like most of other essential oils, cinnamon oils are produced by hydro-distillation (Bhatachajee, 1998). Hydro-distillation is about implies water-cum-steam distillation. To obtain

commercial cinnamon bark oil, broken pieces of quills, pieces of inner bark from twigs and twisted are distilled.

Bark and other parts of the inner bark are placed in a still and direct fire is introduced. The substance produced from the still body is first passed through a pre-cooler and then through a large static water condenser. Recently a precooler has been introduced in between the still body and the static condenser. The precooler cools the distillate to about 70 •C when it is sent into the main condenser and for all the time the precooler is been kept cool by cool water.

Around five to six copper, aluminium or stainless steel Florentine vessels in a cascade arrangement are placed to collect the distillate. As cinnamon oils are heavier than water, condensed oils can be collected at the bottom of vessels. Loading and unloading of the bark is done manually (Agarwall, 1997). The time taken to distill 40-50 kg of bark will take around four to five hours and a yield of 0.5-0.7% of oil on dry weight basis is obtained.

1.3.3 Processing Cinnamon leaf oil

Leaf oil distillations are normally carried out in large distillation vessels of about 200 – 500 kg. Cinnamon leaf are obtained as a by-product of the cinnamon industry. When the shoots are harvested for the bark, the leaves and twigs are trimmed in the field. Before distillation process, the leaf will be left in the field for three to four hours. Traditional leaf

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