SIMPLIFIED THE TREE CROWN MODEL USING MENSURATION DATA

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THIS DISSERTATION IS PRESENTED TO FULFILL THE PARTIAL REQUIREMENT TO OBTAIN A BACHELOR OF SCIENCE DEGREE WITH HONOURS

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ABSTRACT

The crown profile equation was developed based on data measured from 55 *Cinnamomum iners* trees which randomly sampled in the Universiti Malaysia Sabah. At the same time, a simple model for crown shape was also derived using the equation that was introduced by Rautiainen in 2005 based on these data. The parameters that were needed to estimate the crown profile were diameter at breast height (DBH), tree height (HT), crown ratio (CR) and crown length (CL). The correlation matrix was used to identify the relationship between the dependent variable and each of these independent variables. Since the sample size $n \geq 50$, the *Kolmogrov- Smirnov* test was used to test the normality of the data to ensure that the data were always normal. Then the best crown width model can be obtained by using multiple regressions based on the 8 model selection criteria (8SC). After that, the Global test and regression coefficients test were used to ensure that the best model obtained will give the optimum crown shape. The Wald test, however, was not used since the null hypothesis for best model only has one regression coefficient. The results showed that the *C. iners* crown shape was elliptic and the diameter breast height (DBH), crown ratio (CR), crown length (CL), and tree height (HT) will affect the largest crown width of *C. iners* trees.

ABSTRAK

Persamaan untuk menganggar bentuk pokok *Cinnamomum iners* telah diterbitkan berdasarkan data yang telah dikumpul secara rawak di sepanjang jalan pintu masuk ke Universiti Malaysia Sabah. Pada masa yang sama, satu model untuk menganggar bentuk pokok juga diterbitkan dengan menggunakan persamaan yang telah diperkenalkan ole Rautianen pada tahun 2005. Parameter yang digunakan adalah seperti diameter batang pokok (DBH), tinggi pokok (HT), nisbah pokok (CR) dan panjang pokok (CL). Matriks korelasi digunakan untuk mengesahkan hubungan antara pembolehubah bersandar dengan pembolehubah tidak bersandar. Oleh kerana saiz sample $n \geq 50$, maka ujian *Kolmogrov-Smirnov* digunakan untuk mengesahkan kenormalan data. Model yang paling baik boleh disahkan dengan menggunakan lapan ujian untuk menguji kejituan model (8SC). Selepas mendapat model yang terbaik, Ujian Seluruh dan Ujian Individu digunakan untuk mengesahkan model yang terbaik ini akan menberikan bentuk pokok yang maksimum dan objektif akan dicapai. Manakala, Ujian Wald tidak dapat dijalankan kerana hanya terdapat satu pekali regresi dalam hipotesis nol untuk model terbaik. Keputusan menunjukkan bentuk pokok *C. iners* adalah dalam bentuk elips dan diameter batang pokok (DBH), tinggi pokok (HT), nisbah pokok (CR) dan pangjang pkok (CL) boleh mempengaruhi pertumbuhan pokok.

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LIST OF SYMBOLS

%	Percentage
μm	Micrometer
α	Level of significance
σ^2	Variance
β	Regression coefficient
ε	Error term
Ψ	Percentages of reading
Ψ_b	Percentages of base reading
Ψ_t	Percentages of top reading
BLUE	Best linear unbiased estimator
c	Total length of crown above R_{max}
CL	Live crown length
CPA	Crown projection area
CR	Crown ratio (CL/HT)
CW_h	Crown width at height h
DBH	Diameter breast height
DF	Degrees of freedom
h	Height above the ground to the crown width of interest (CW_h)
h_{eyes}	Eye's height
HT	Total height
HLCW	Height above the ground to LCW
ISO	International Organization for Standardization
k	Number of parameters
LAI	Leave area index
LCL	Light crown length
LCW	Largest crown width of a stand-ground tree
m	metre

mm	millimetre
MCW	Maximum crown width of an open-grown tree
n	Number of observations
OLS	Ordinary least square
R	Crown radius
R_{max}	Maximum crown radius
SSE	Sum of square of error
SSR	Sum of square of residual
SSE_R	Sum of square of error for resticted model
SSE_U	Sum of square of error fro unrestricted model
tan	Tonne
UK	United States of America
UMS	Universiti Malaysia Sabah
US	United Kingdom

CHAPTER 1

INTRODUCTION

1.1 What is *Cinnamomum iners*?

Cinnamomum is a genus of evergreen trees belonging to the family Lauracea. The scientific name of *cinnamom iners* is *cinnamomum iners Reinw. ex Blume* (Phutdhawong *et al.,* 2007). This genus has over 300 species and it is located in the tropical rainforest and the subtropical rainforest of South America, North America, Central America and Asia. Some of the species of *cinnamomum* are *cinnamomum aromaticum*, *cinnamomum iners*, *cinnamomum verum*, *cinnamomum cassia* and many others.

The name cinnamon comes from the Greek word 'kinnámōmon' and it means sweet wood (Babu *et al.,* 2004). In Malaysia, its name is given by kayu manis or medang tija. Kayu manis also means sweet wood. In the same time, it is also known as wild cinnamon or clove cinnamon. *Cinnamomum* is native to southern India, Sri Lanka and Myanmar (Burma), also cultivated in South America and the West Indies.

1.1.1 History of Cinnamomum

Miller (1969), a historian has mentioned that as early as the second millennium BC, cassia and cinnamon from China and South- East Asia might have been brought from Indonesia to Madagascar in primitive canoes, along a "cinnamon route" which might have existed at that time. Parry (1969) was of opinion that the founders of the spice trade between India and the rest of the world were either the Phoenicians or the Arabs. Most of the accomplished sailors were Phoenicians; they might have the responsibility to bring the cinnamon from the east to the west. There were also references about Arabian trades carrying spices. Cinnamon is said to be more valuable than gold (Farrell, 1985). They were among the most valuable medical plants for ancient Greeks and Romans. The rise of the Roman Empire has broken the domination of spice trade of Arab. Mariner Hippalus had traveled to India to discover the trade wind system around AD 40 and thereby opening up the direct trade route between Rome and West Coast of India. As a result, the use of spices in Rome had grown unexpectedly. In AD 66, the emperor Nero is said to have a burned a year's supply of Rome's cinnamon at his wife's funeral pyre. It was also customary for men to be heavily perfumed and even "the legionaries reeked for the fragrances of the east" (Rosengarten, 1969). The lamp oil also mixed with aromatics to keep away from the harmful vapours.

In AD 410, Rome captured by Alaric the Gothic. Once again the Arabs came in and soon became the masters of the spice trades. This monopoly continued till the fifteenth century, when the sea route to India was discovered and Vasco- da- Gama

landed in the West Coast of India on 20 May 1498 (Babu *et al.,* 2004). According to Parry (1969), spices started reaching Western Europe during the Middle Ages which is between fifth and fifteenth centuries. A spice is one of the choices gift to royalty and the privileged, especially to the monasteries and ecclesiastical establishments. Other than that, Parry (1969) was also noticed that, spices like pepper, cardamom, cinnamon and cassia contributed greatly to European cooking. This is because cinnamon is widely used in spices. Other places like Egypt, the ancient Egyptians used it to flavour varieties of foods. The request for spices opened up the era of great expeditions. As a result, the Columbus discovered America and Vasco- da- Gama had sail to eastwards round the Cape of Good Hope and finally arrived in India. By the beginning of sixteenth century, the Portuguese started direct trading in spices with the Malabar Coast, and with this the Arab monopoly on spices came to an end (Babu *et al.,* 2004). This Portuguese supremacy led to an increasing price pepper and cinnamon. In order to break this monopoly, the other West European countries were sent out many expeditions to establish a route to Malabar Coast and the spice island of the East Indies.

During 1596, the Dutch navigator Cornelius Van Hortman reached the East Indies and gradually conquered all important spice- producing islands. The Dutch captured the Portuguese establishments in Ceylon in 1658. Then in 1796, Ceylon occupied by British, and the monopoly of cinnamon trade changed again. During the colonist of British and Dutch, cinnamon was introduced to many other islands in the tropics. In 1798, cinnamon was introduced into India by Mr. Murdock Brown and he established a cinnamon plantation in the Anjarakandy Estate, which still exists. Ceylon still remained as the major

producer of cinnamon while cinnamon was spread to other regions. In 1876, quills and chips were introduced as export products (Wijesekara *et al.,* 1975). The global production and trade in spices were affected drastically by the world wars. The Dutch East Indies occupied by the Japanese had led to the decline of spice production and the western countries imports also declined sharply. After the end of Second World War, most of the colonial country gained independence and spices became one of their major export earnings.

1.2 Uses of *Cinnamomum iners*

1.2.1 Commercial Value

In the world trade, Sri Lanka cinnamon is centered in London and the Dutch ports of Amsterdam and Rotterdam. These are the main transshipment points for the leading buyers such as Mexico, US, Germany, Colombia (Babu *et al.,* 2004). Sri Lanka contributes about 80%- 90% to the world market; however the rest comes from Madagascar and Seychelles. Cinnamon bark oil is a high-value essential oil but the volumes traded are very low. The major market is the European Union, within which France is the main importer. In recent years the United States has emerged as the second largest importing country. At the same time, United States and Western Europe are the largest markets for cinnamon leaf oil.

The commercial product of cinnamon is quills, quillings, featherings, chips, oils extracted from cinnamon barks and leaves. There is a difference between quills and quillings. Quills defined as the long compound rolls of cinnamon bark measuring up to 1 meter in length. However the quillings was define as the breakages obtained during grading and transportation. It is small pieces of bark left after the preparation of quills. The taste and smell of quillings are same as quills, even though qullings are considered as medium class of cinnamon. The chips of cinnamon are defined as the bark that obtained from thick branches and stems. Trimming of the cut shoots, shavings of the outer and inner barks and odd pieces of outer barks also considered as chips of cinnamon. Actually the chips are not peeled out from the stem. Instead, they are scrapped off from the greenish brown, mature, thick pieces of bark, which is considered as inferior cinnamon. Experienced peelers used to make the cinnamon quills in uniform thickness from end to end. The dried quills are tightened into small bundles. Quills are graded depending on their size, foxings and colour. Foxings is dark brown patches that can be found on the surface of quills. Quills that are free from foxing are grouped as best quality. In the process of making quills, there left some small pieces of inner bark consisting of shavings, which is called featherings (Babu *et al.,* 2004).

1.2.2 Industrial

Cinnamon wood is commonly used to make furniture, food containers, toys and house building. The timber of *C. iners* has an aromatic smell and it can protect the timber to be

slowly destroyed by insects. The cinnamon woods having a strong smell, polishes well and it is very useful for cabinet making (Babu *et al*., 2004).

1.2.3 Essential Oil

Essential oils are the volatile oily components of aromatic plants, trees and grasses. Essential oils are extracted by four main methods that are steam distillation, expression, solvent extraction and enfleurage. In steam distillation method, the oil is extracted by the action of hot steam and then selectively condensed with water from which it is separated. Steam distillation method is a common technique to obtain the aromatic compounds from plants. Sloley, (2001) has mentioned that the process of distillation is maybe either heated by the direct application of fire or the liquid in the still raised to the boiling point to the injection point of steam. In the expression method, the oil is extracted by pressure or centrifugation. Centrifugation is a process that using centripetal force to separate some mixtures. According to Silva *et al.* (2005), solvent extraction is a separation and concentration process in which a non- aqueous liquid is used to remove organic contaminants. In this method, the oil is dissolved in a volatile solvent. After that it evaporated leaves a heavily natural wax substance called concrete, which is a mixture of essential oil, waxes, resins, and other oil soluble of plant material. When separated from the wax, the resulting liquid is called an absolute, the most concentrated form of aroma available. Enfleurage is a very long and second step process involving the dissolution of the oils in animal fat and it's extracted with alcohol. This method is used to extract delicate flora aromas by solution and adsorption into fat. Although essential oils main

usage is in cosmetics and perfumery, many of them do have proved therapeutic properties. For example, aromatherapy is a form of alternative medicine that uses essential oil for the purpose of affecting a person's mood or health. Home aromatherapy, clinical aromatherapy and aromachology are the main branches of aromatherapy. One of the best known essential oils for aromatherapy is lavender, which is recommended by practitioners for treating wounds, to enhance memory, and to aid sleep by combating anxiety and insomnia (Adam, 2006). Other popular scents include eucalyptus, rose, jasmine and bergamot. One of the advantages using aromatherapy is to relieve tension. By adding a few small drops of essential oils to a pot of boiling water, the room will begin to fill with a pleasing scent. Essential oils such as Lavender, Pine, Peppermint, Jasmine, Orange, and Chamomile help us to relax the body and mind. Essential oils such as Lemon, Rosemary and Cedar wood help to stimulate our body and our mind, and give us energy. Essential oils such as Ginger, Clove, Black Pepper, and Marjoram help to warm up our body (these oils are often directly applied to the skin).

1.2.4 Oils Extracted from Leaves and Barks

In the world market, the oils from the Cinnamon species are classified as cinnamon oil, cassia oil and camphora oil, according to the place of origin (Babu *et al.,* 2004). The true cinnamon oils that classified as "Cinnamon Leaf Oil" (ISO 3524) are come from Sri Lanka. The most important Cinnamon oils in world trade are those from *Cinnamomum Verum* (cinnamon bark and leaf oils), Cinnamomum Cassia (cassia oil) and *Cinnamomum Camphora*. There is only one category exists in cassia oil because the leaves and twigs

are distilled together during the process of distillation cassia oil (Babu *et al.,* 2004). The latter species provides oils which are utilized as sources of chemical isolates. However, a number of other Cinnamon species are distilled on a smaller scale and the oils used either locally or exported to regional markets. For example, *Cinnamomum iners* oils have the greatest potential for future use. Oils extracted from cinnamon bark possess the delicate aroma of the spice and a sweet and pungent taste. It is employed mainly in the flavouring industry where it is used in meat and fast food seasonings, baked goods, confectionery, soft drinks, tobacco flavours and in dental and pharmaceutical preparations. Normally the value of cinnamon bark oils are depends on the material that is used to distil the oil (Babu *et al.,* 2004).

1.2.5 Beauty Care

Cinnamon bark oil is used to give a woody and musky undertone to perfumes (Babu *et al.,* 2004). Perfumery applications are far fewer than in flavours because the oil has some skin-sensitizing properties.

Cinnamon bark oil contains highly irritant, therefore it is not widely use in this way. Occupational allergic contact dermatitis is occasionally observed among those who work with this spice (Kanerva *et al.,* 1996). At the same time, it is also fragrance to soaps, flavour dentifrices and mouthwashes. Leaf oil also fragrance to soaps and other such toiletries. Besides that cinnamon is useful to cure acne, headaches, lumps and pustules when it mixed with pepper and clove, then applied it as a facial mask.

1.2.6 Medicine

The roots have been traditionally used for the treatment of rheumatism and fever. It can also be a cure for colds. It has been used to treat diarrhoea and other problems of the digestive system. Leaves are tradisionally used as an analgesic and antipyretic (Pormjit *et al.,* 1989). Analgesic commonly known as a painkiller and it can be used to relieve pain. Analgesic drugs act in various ways on the peripheral and central nervous systems. On the other hand, antipyretic is a drug which can reduce or prevent fever by reducing the body temperature from a raised state. Most of it also is used for other purposes. Cinnamon was components of medicine recommended for coughs, chest pain, headache, digestion and gas problems (Babu et *al.,* 2004).

> Cinnamon can provoke urine, it help to clear the eyes and made the breath sweet. An extract of cinnamon would bring down the menses and would counteract the stings and bites of venomous beasts, reduce the inflammation of the intestines and kidneys, comfort the stomach, break wind, would aid in digestion and when mixed with honey would remove spots from the face (Farrell, 1985).

As an antiseptic it is used as an injection in gonorrhea. In the Ayuverda and Sidba medical systems, cinnamon bark, twigs, leaves and oil are used as ingredients of many multidrug preparations (Babu *et al.,* 2004). They also mentioned that, since cinnamon bark and oil contains many different chemical constituents, it is logical to assume that

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