SOIL NITROGEN AND PHOSPHORUS AND TEA LEAF GROWTH IN ORGANIC AND CONVENTIONAL FARMING OF SELECTED FIELDS AT SABAH TEA PLANTATION SLOPES.

HO TECK YUNG

THIS DISSERTATION IS SUBMITTED AS A PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR BACHELOR OF SCIENCE WITH HONOURS

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DECLARATION

I declare that this dissertation is the result of my own work except for the quotations and citations which have been duly acknowledgement.

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ABSTRAK

Teh telah menjadi salah satu minuman kegemaran di kalangan pengguna disebabkan oleh sifat-sifat farmakologikal yand dimiliki. Namun, pokok teh menyerap nutrient-nutrient penting dari tanah bagi memastikan perkembangan dan pertumbuhan yang sihat. Dengan itu, kajian telah dijalankan di dua ladang terpilih; ladang B29 (ladang konvensional) dan ladang NO3 (ladang organik) di Sabah Tea Plantation (STP) bagi mempelajari kesan sistem pertanian dan peringkat kecerunan ke atas nitrogen, fosforus dan pH dalam tanah serta pertumbuhan daun. Cerun di setiap ladang dibahagikan kepada tiga peringkat iaitu atas, tengah dan bawah. Sejumlah 18 replikat tanah dan 108 sampel daun dikumpul dari kedua-dua cerun di dalam dua ladang. Kepekatan ammonium, nitrat dan fosforus di dalam sampel tanah masing-masing diuji dengan menggunakan Kaedah Biru Indofenol, Kaedah Asid Salisilik dan Kaedah Mehlich-3. Nilai pH tanah diperolehi menggunakan meter pH dengan nisbah tanah kepada air, 1:2.5. Pengukuran daun dilakukan secara manual menggunakan pembaris. Kesan daripada dua faktor ke atas enam pembolehubah diuji dengan menggunakan ujian ANOVA dua hala dan Post Hoc Turkey yang terkandung dalam perisian SPSS versi 12.0. Keputusan menunjukkan bahawa sistem pertanian organik (SPO) menghasilkan pH tanah (4.14), kepanjangan daun (15.14 cm) dan kelebaran daun (7.33 cm) yang lebih tinggi berbanding sistem pertanian konvesional (SPK) (pH tanah – 3.38; kepanjangan daun – 13.19 cm; kelebaran daun – 5.58 cm). Walau bagaimanapun, SPK mengandungi kandungan ammonium yang lebih tinggi (166.16 $\mu g\ ml^{-1}$) berbanding SPO (22.56 $\mu g\ ml^{-1}$). Tiada perbezaan yang bermakna pada kandungan fosfosus dan nitrat dalam tanah dapat diperhatikan di antara dua sistem pertanian. Keputusan yang diperolehi juga menunjukkan bahawa faktor cerun tidak mempunyai kesan yang bermakna ke atas enam pembolehubah. Kajian ini menunjukkan bahawa SPO bukan sahaja mempertingkatkan pertumbuhan daun teh, malahan juga memperbaiki tahap pH dalam tanah. SPO merupakan satu sistem pertanian yang lebih baik dan ia adalah sepatutnya diamalkan dalam pengeluaran teh.

ABSTRACT

Tea has become one of the most popular drinks due to its pharmacological properties. However, tea plants absorb its essential nutrients mainly from soils for growth and development. Thus, this study was done at two selected fields; B29 (conventional field) and NO3 (organic field) in Sabah Tea Plantation (STP) to study the effects of farming system and slope section on nitrogen, phosphorus, soil pH and leaf growth. Slope in each field was divided into three sections; top, middle and low. About 18 soil replicates and 108 tea leaves were sampled from both slopes in the two fields. The concentration of ammonium, nitrate and phosphorus in soil samples were analyzed using Indophenol Blue method, Salicylic Acid method and Mehlich-3 test, respectively. Soil pH was measured using pH meter with soil-water ratio of 1:2.5. Leaf measurement was done manually using ruler. The effects of the two factors on six parameters were analyzed with SPSS software version 12.0 using two-way ANOVA and Post Hoc Turkey test. Results showed that organic farming system (OFS) produced higher soil pH (4.14), leaf length (15.14 cm) and leaf width (7.33 cm) than conventional farming system (CFS) (soil pH - 3.38; leaf length - 13.19 cm; and leaf width - 5.58 cm). However, CFS produced higher levels of ammonium content (166.16 $\mu g\ ml^{-1}$) than OFS (22.56 $\mu g\ ml^{-1}$). No significant difference in soil phosphorus and nitrate content were observed between the two farming systems. Results also showed no significant effects of slope levels on all parameters studied. The study shows that OFS not only improve tea leaf growth but also the pH level of soil, suggesting that OFS is a better farming system to be practiced in tea production.

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LIST OF SYMBOLS

%	Percentage
=	Equal
x	Multiply
/	Per
$H_2PO_4^-$	Dihydrogen phosphate
HPO_4^{2-}	Orthophosphate or hydrogen phosphate
N	Nitrogen monoxide or nitrogen (II) oxide
N_2	Elemental Nitrogen
N_2O	Nitrous Oxide or Dinitrogen Oxide
NH_4^+	Ammonioum
NO	Nitrogen monoxide or nitrogen (II) oxide
NO_3^-	Nitrate
P	Phosphorus

UNITS

°C	Degree Celsius
µg	Microgram
cm	Centimeter
g	Gram
kg	Kilogram
L	Liter
M	Molar
mg	Milligram
ml	Milliliter
mm	Millimeter
nm	Nanometer
ha	Hectare
ppm	Parts per million
M	Molar

LIST OF ABBREVIATIONS

CFS	Conventional farming system
OFS	Organic farming system
STP	Sabah Tea Plantation
SPK	Sistem pertanian organik
SPO	Sistem pertanian konvensional
UV	Ultraviolet

CHAPTER 1

INTRODUCTION

1.1 Introduction

As population pressure keeps increasing, productive land all over the world is becoming increasely scarce (Peck *et al*., 1977). Consequently, this has resulted in soil fertility researches around the world shifting their focus towards sustainable production (Smaling and Braun, 1996). Good soil management of soil organic matter dynamics and nutrient cycling is one of the ways towards sustainable production (Six *et al*., 2004).

Soil is a complex biogeochemical material on which plants may grow (Singer and Munns, 2002). It serves as the most important resource of mankind in feeding and clothing the world (Schnug, 1996). Besides, soils have been known as the major factor which limits types of vegetation and crops (Gupta, 2003).

The growth and development of plants are highly dependent on the nutrient available in soils (Salisbury and Ross, 1992). Plants require major and trace elements in its nutrition to ensure the plant proceed through every physiological stage of its growth cycle (Cresser *et al.*, 1993). The availability of these major (nitrogen, phosphorus, potassium, magnesium, calcium and sulphur) and trace elements (boron, copper, iron and zinc, molybdenum) is mainly constrained by soil physical and chemical properties (Paul and McLaren, 1975).

Types of agriculture practices such as conventional and organic farming can affect soil physical, chemical and biological characteristics as well as nutrient availability in a long-run (Schjønning *et al.*, 2002). Between these two farming practices, it is widely accepted that organic farming is a relatively environmental friendly production system (Hansen *et al.*, 2001). In general, organic farming resulted in significant increase in nitrogen and phosphorus content as compared to conventional farming (Melero *et al.*, 2006).

There is no doubt that health will always be the main concern to people (Oak *et al.*, 2005). Tea has become one of the most popular drinks and beverages around the world due to its high pharmacological properties (Yamamoto *et al.*, 1997). Tea has been scientifically shown to possess antioxidative, cancer chemoprevention, dental caries prevention and deodorizing functions (Yamamoto *et al.*, 1997; Roger, 2001). Two of the largest tea plantations in Malaysia are Cameron Highlands Tea Plantation in Pahang, and Sabah Tea Plantation in Sabah.

From the literature, very little research about soil nutrient content and its effects on tea leaf growth has been done on Sabah Tea Plantation, especially in soils under conventional and organic farming systems. Furthermore, Dang (2004) reported that imbalance of nutrients in soil-plant system is considered a cause of long-term soil quality degradation in tea plantation. Therefore, this study is being conducted to compare nitrogen and phosphorus content and its effects on tea leaf growth in soil under conventional and organic farming systems of two fields at Sabah Tea Plantation.

Plants absorb its essential nutrients mainly from soils (Tisdale and Nelson, 1975). So, the results from this study will provide a basis for understanding the influence of different agriculture practices on soil nutrients contents as well as plant growth. Nitrogen and phosphorus are of interest in part because of their important roles in plant growth and development (Salisbury and Ross, 1992).

1.2 Research Objectives

The objectives of this study are to:

a) Compare the soil nitrogen and phosphorus content and tea leaf growth in organic and conventional farming systems at Sabah Tea Plantation.

b) Compare the soil nitrogen and phosphorus content and tea leaf growth at different slope levels at Sabah Tea Plantation.

CHAPTER 2

LITERATURE REVIEW

2.1 Soils

Soil is the most important medium where plants and crops may grow. Soils play enormous roles in plant growth and development. Soil hold the water for plant use, serve as the medium for plant to hold them up to the sun (Singer and Munns, 2002), serves as a sink for organic carbon (Wiseman and Püttmann, 2006), and the most important is, as a source of nutrient (Paul and Mclaren, 1975).

Plants need nutrient elements to grow. They get carbon, oxygen, and hydrogen from air and water, but all other nutrients come from the soil. The sources of major nutrients such as nitrogen, phosphorus and sulphur arise from biological processes such as transformaiton of nitrogen, phosphorus and sulfur compounds which can only occur in soil with the help of soil-borne microbes (Huang, 2004).

Nutrient retention and movement are regulated by soil with the influence of other factors such as pH, temperature, moisture and microbial activity. The most important component of soil in holding nutrients are the clays and humus whose its surfaces can chemically retain nutrients in forms that plants can use (Dixon, 1991).

2.1.1 Sandy Loam Soils

Sabah Tea Plantation (STP) soils are predominantly sandy loam soil (Personal communication, Mr. Jeffry, STP). Sandy loam soil refers to soil materials that contain 7 to 20% clay, more than 52% sand, and the percentage of silt plus twice the percentage of clay is 30 or more (USDA, 2006a). Sandy loam soil is well drained, has high water holding capacity with average pH of 4.2 (Ismail *et al.*, 2007). Basically, soil texture can be differentiated by feel (Table 2.1). Sandy loam soil when squeezed moist, form a cast that can be gently handled (Singer and Munn, 2002).

Table 2.1 Guidelines for estimating texture by feel (Singer and Munns, 2002) and the content for each texture of soil (USDA, 2006a).

Texture	Guidelines	% of sand, silt and clay
Sand and loamy sand	Individual grains easily seen and felt; when squeezed moist, form a cast that crumbles when touched.	85% or more sand, % of silt plus 1.5 times % of clay is less than 15.
Sandy loam	When squeezed moist, forms a cast that can be gently handled.	7 – 20% of clay, more than 52% sand the % of silt plus % of clay is 30 or more.
Loam	Gritty feel but fairly smooth; when squeezed moist, forms a cast that can be freely handled without breaking.	7 – 27% clay, 28 – 50% silt and less than 52% sand.
Silt loam	Soft and floury when dry; form a cast when dry or moist, but when squeezed between thumb and forefinger, will not ribbon when moist.	50% or more silt and 12 – 27% clay
Clay loam	Forms a thin ribbon that barely sustains its own weight; moist soil is plastic and forms a cast that can be handled.	27 – 40% clay and 20 – 45% sand
Clay	Sticky and plastic when wet, forms a strong ribbon.	40% or more clay, less than 45% sand and less than 45% silt.

2.2 Tea (*Camellia sinensis*)

"Tea Plant" is an evergreen, tree-like shrub which can grow to a height of 10 meters in the wild and one to two meters when cultivated. It has elliptic leaves, alternate, waxy, thin-leathery and 5 - 10 cm long. The flowers are usually finely serrate, small in size, white in color and fragrant. Tea is normally gently heated, rolled and fermented to produce the aromatic black tea of commerce (Graf, 1992). Tea was native to southwest Asia, China and India, where it still grows wildly (Roger, 2001).

2.2.1 Tea Taxonomy

The plant Kingdom is very diverse (Valder, 1999). Thus it is necessary to arrange plant profiles in a systematic way so that it can be referred and managed easily. Based on the United States Department of Agriculture's plants profiles (USDA, 2006b), profiles for *Camellia sinensis* variety *sinensis* and *assamica* are described as in Table 2.2.

2.2.2 Tea Origin and Area of Cultivation

The tea plants, being cultivated at Sabah Tea Plantation belong to the variety of *assamica* and *sinensis*. Spontaneous growth of *Camellia sinensis* var. *assamica*, whose leaf is larger (leaf length and width, 16-19 cm x 7-9 cm) and trunk is tall, are in various areas lying between Yun-nan province of China to the northern region of Myanmar and Assam region of India (Yamamoto *et al.*, 1997).

Camellia sinensis var. *sinensis*, whose leaf is small (leaf length and width, 5.5-6.1 cm x 2.2-2.4 cm) with bushy trunk, are found in the eastern and southeastern districts of China (Yamamoto *et al*., 1997).

Table 2.2 Complete profiles of *Camellia sinensis* (L.) O Kuntze var. *sinensis* and *assamica* (USDA, 2006b).

Scientific Classification	Var. *sinensis*	Var. *assamica*
Kingdom	Plantae	Plantae
Subkingdom	Tracheobionta	Tracheobionta
Superdivision	Spermatophyta	Spermatophyta
Division	Magnoliophyta	Magnoliophyta
Class	Magnoliopsida	Magnoliopsida
Subclass	Dilleniidae	Dilleniidae
Order	Theales	Theales
Family	Theaceae	Theaceae
Genus	*Camellia* L.	*Camellia* L.
Species	*Camellia sinensis* (L.) O. Kuntze	*Camellia sinensis* (L.) O. Kuntze
Variety	*Camellia sinensis* (L.) O. Kuntze var. *sinensis*	*Camellia sinensis* (L.) O. Kuntze var. *assamica* (J. Masters) Kitam

Based on FAO (2007) statistical yearbook 2005/2006, the main global tea producer in 2004 as shown in Table 2.3 are China (25.6% of world production), India (25.5%), Sri Lanka (9.2%), Kenya (8.8%) and Turkey (6.0%). Black tea dominates world tea production, accounting for more than 70 percent of the global total in 2004. Green tea production has, however, continued to increase its share of the world total, largely due to China's heavy focus on green tea. About 76 percent of China's production is green tea.

The largest importers, in terms of value imported, are the Russian Federation (9.6 % of the world total), UK (9.5 %), USA (6.7 %), Pakistan (6.2 %), and Egypt (0.14 %). Together these five countries account for nearly one-third of total world imports, which totalled $ 3,059,002 in 2004 (Table 2.3).

Tea exports are dominated by developing countries which account for 90 percent of the world total, with the major exporters in 2003 being Sri Lanka (22.4 % of the world total), Kenya (14.2 %), China (14.2 %) and India (11.5 %). Together these four countries accounted for 62.3 % of the world exports of $ 3,271,661 in 2004 (Table 2.3).

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