

**THE EFFECTS OF THE BLENDED FERTILIZER BETWEEN
CENTRIFUGED RESIDUE OF RUBBER LATEX AND SWINE
MANURE FOR THE GROWTH ENHANCEMENT OF PARA
RUBBER (SEEDLING)**


THANYA UTTRAPORN


**A THESIS SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR
THE DEGREE OF MASTER OF SCIENCE
(APPROPRIATE TECHNOLOGY FOR RESOURCE
AND ENVIRONMENTAL DEVELOPMENT)
FACULTY OF GRADUATE STUDIES
MAHIDOL UNIVERSITY
2011**


COPYRIGHT OF MAHIDOL UNIVERSITY


Thesis
entitled


**THE EFFECTS OF THE BLENDED FERTILIZER BETWEEN
CENTRIFUGED RESIDUE OF RUBBER LATEX AND SWINE
MANURE FOR THE GROWTH ENHANCEMENT OF PARA
RUBBER (SEEDLING)**


.....
Miss Thanya Uttraporn
Candidate


.....
Assoc. Prof. Rungjarat Hutajareon,
M.Sc. (Technology of Environmental
Management)
Major advisor



.....
Assoc. Prof. Sayam Aroonsrimorakot,
M.Sc. (Technology of Environmental
Management)
Co advisor

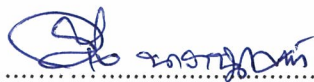

.....
Prof. Banchong Mahaisavariya,
M.D., Dip Thai Board of Orthopedics
Dean
Faculty of Graduate Studies
Mahidol University



.....
Assoc. Prof. Sayam Aroonsrimorakot,
M.Sc. (Technology of Environmental
Management)
Program Director
Master of science Program in Appropriate
Technology for Resource and Environmental
Development
Faculty of Environment and Resources Studies
Mahidol University


Thesis
entitled
**THE EFFECTS OF THE BLENDED FERTILIZER BETWEEN
CENTRIFUGED RESIDUE OF RUBBER LATEX AND SWINE
MANURE FOR THE GROWTH ENHANCEMENT OF PARA
RUBBER (SEEDLING)**

was submitted to the Faculty of Graduate Studies, Mahidol University
for the degree of Master of Science
(Appropriate Technology for Resource and Environmental development)
on
March 16, 2011



.....
Miss Thanya Uttraporn
Candidate


.....
Assoc. Prof. Charlie Navanugraha,
Ph.D. (Soil Science)
Chair


.....
Assoc. Prof. Sayam Afoensrimorakot,
M.Sc. (Technology of Environmental
Management)
Member


.....
Assoc. Prof. Rungjarat Hutajareon,
M.Sc. (Technology of Environmental
Management)
Member


.....
Prof. Banchong Mahaisavariya,
M.D., Dip Thai Board of Orthopedics
Dean
Faculty of Graduate Studies
Mahidol University


.....
Asst. Prof. Sittipong Dilokwanich,
M.Sc. (Human Geography)
Dean
Faculty of Environment and Resources Studies
Mahidol University

ACKNOWLEDGEMENTS

The success of this thesis can be attributed to the extensive support and assistance from my major advisor, Assoc. Prof. Rungjarat Hutajaroen and my co - advisor, Assoc. Prof. Charlie Navanugraha for his supervision, critical reading of draft and his time for correction and editing my thesis. I am grateful to my co – advisor, Assoc. Prof. Sayam Aroonsrimorakot, Asst. Prof. Gritsanaruck Theeraraj and Asst. Prof. Saranya Sucharitakul for their kindness, valuable advice, several helpful discussions and providing suggestions for improvement this research.

I wish to thank Sri Trang Agro-Industry Public Company Limited for the centrifuged residue of Para rubber and Mr. Thanongsuk Wannachod for swine manure to carry out this thesis.

My special thanks is given to Koko [AT 22] for her lots of help, thinking and for all her kindness to do everything that she could. Thanks to all friends, AT 22, AT 23, for their friendship and all enjoyable thing that we have ever done throughout my study.

Most of all, my sincere and deepest gratitude is extended to my beloved family; my parents, sister, brother, uncles and aunts for their insight, infinite supporting, understanding, supervision assistance and constant encouragement throughout my study time. I really could not achieve this success without them.

Thanya Uttraporn

THE EFFECTS OF THE BLENDED FERTILIZER BETWEEN CENTRIFUGED RESIDUE OF RUBBER LATEX AND SWINE MANURE FOR THE GROWTH ENHANCEMENT OF PARA RUBBER (SEEDLING)

THANYA UTTRAPORN 5036346 ENAT/M

M.Sc. (APPROPRIATE TECHNOLOGY FOR RESOURCES AND ENVIRONMENTAL DEVELOPMENT)

THESIS ADVISORY COMMITTEE: RUNGJARAT HUTAJAREON, SAYAM AROONSRIMORAKOT, M.Sc.

ABSTRACT

Centrifuged residue from rubber latex is the by-product of the waste from the concentrated latex process. Production of 100 kg of fresh latex could provide 10 kg of centrifuged residue. This has been a waste disposal problem for the latex factory. Practical disposal methods have been used by the factory, such as landfill, burying it in soil, and burning it. These have been seen as wasteful practices and have caused environmental pollution. Analysis has shown that the centrifuged residue contains some mineral nutrients (N, P, K) in the form of substances for plants to utilize instantly. However, the centrifuged residue still has some small rubber pieces mixed within and needs to be blended. While swine manure also contains some essential plant nutrients, it takes some time to decompose for utilization as an organic compound suitable for plants. Thus, four fertilizer formulas were designed for this research: Formula 1, the chemical fertilizer formula 20-8-20; Formula 2, a mixture of centrifuged residue and swine manure in a 1:1 proportion, with adjusted N-P-K elements with chemical substances of the concentration 20-8-20; Formula 3, the mixture of centrifuged residue and swine manure in the proportion of 1:1; Formula 4, control set. The experiment was planned with a completely randomized design (CRD) with 15 replications. The Para rubber seedling in the Family PRIM 600 variety, age 2 months, was selected as the study sample. Seedling growth was measured every 15 days for height, tree diameter, and number of leaves for the 90 day experiment.

The research findings showed that it was possible to substitute the fertilizer Formula 2 for the fertilizer Formula 1 equally in terms of seedling growth, when considering height, tree diameter, and number of leaves. Furthermore, the fertilizer Formula 2 provided the most Para rubber plant growth in height, trunk diameter, and number of leaves with statistical significance at $p < 0.05$.

KEY WORDS : RUBBER LATEX RESIDUE / SWINE MANURE / BLENDED FERTILIZER / PARA RUBBER SEEDLING

117 pages

ผลของการใช้ปุ๋ยผสมกากจี้แบ่งจากกระบวนการผลิตน้ำยางข้นและมูลสุกรต่อการเจริญเติบโตของกล้ายาง

THE EFFECTS OF THE BLENDED FERTILIZER BETWEEN CENTRIFUGED RESIDUE OF RUBBER LATEX AND SWINE MANURE FOR THE GROWTH ENHANCEMENT OF PARA RUBBER (SEEDLING)

ชัญญา อุตราภรณ์ 5036346 ENAT/M

วท.ม. (เทคโนโลยีที่เหมาะสมเพื่อการพัฒนาทรัพยากรและสิ่งแวดล้อม)

คณะกรรมการที่ปรึกษาวิทยานิพนธ์ : รุ่งจรัส หุตะเจริญ, วท.ม., สยาม อรุณศรีมรกต, วท.ม.

บทคัดย่อ

กากจี้แบ่งเป็นของเสียที่เกิดจากกระบวนการผลิตน้ำยางข้น โดยการผลิตน้ำยางสด 100 ก.ก. จะมีปริมาณกากจี้แบ่งอยู่ 10 ก.ก. ซึ่งเป็นภาระของโรงงานที่จะต้องทำการกำจัด อาจโดยใช้วิธีฝังกลบ, ถมที่ หรือ เผาทิ้ง ที่ไม่มีการใช้ประโยชน์ และเป็นภาระกับสิ่งแวดล้อมต่อไป ทั้งนี้มีการศึกษาที่พบว่า กากจี้แบ่งมีธาตุอาหาร N,P,K ที่อยู่ในรูปสารประกอบที่พืชจะใช้ประโยชน์ได้ทันที แต่มีเศษยางเจือปนอยู่บ้าง ในขณะที่มูลสุกร มีธาตุอาหารต่างๆที่มีประโยชน์กับพืชแต่ต้องใช้เวลาในการย่อยสลาย เพื่อให้สารประกอบเหล่านั้นอยู่ในรูปที่พืชนำไปใช้ประโยชน์ได้ ดังนั้นในการศึกษารุ่นนี้ได้พัฒนาปุ๋ยผสมขึ้นมา 4 สูตร คือสูตรที่ 1 เป็นปุ๋ยเคมีสูตร 20-8-20, สูตรที่ 2 เป็นกากจี้แบ่งผสมมูลสุกรในอัตราส่วน 1:1 และปรับค่า N-P-K ด้วยปุ๋ยเคมี จนมีความเข้มข้น 20-8-20, สูตรที่ 3 เป็นกากจี้แบ่งผสมมูลสุกรในอัตราส่วน 1:1 และสูตรที่ 4 เป็นชุดควบคุม มีการวางแผนการทดลองแบบสุ่มตลอด (Completely randomized design, CRD) จำนวน 15 ซ้ำ ดันยางพาราที่ใช้ในการศึกษาเป็นพันธุ์ RRIM 600 อายุ 2 เดือน การศึกษามีการติดตามวัดผลการเจริญเติบโตของต้นกล้ายางทุกๆ 15 วัน ในด้านความสูงต้น ขนาดเส้นผ่าศูนย์กลาง และจำนวนใบ เป็นระยะเวลา 90 วัน

การศึกษพบว่าปุ๋ยผสมสูตรที่ 2 สามารถทดแทนปุ๋ยผสมสูตรที่ 1 ได้อย่างเท่าเทียมกัน เมื่อพิจารณาจากความสูง ขนาดเส้นรอบวง และจำนวนใบ อีกทั้งยังพบว่าในปุ๋ยผสมสูตรที่ 2 มีผลให้ต้นกล้ายางมีการเจริญเติบโตที่ดีกว่าชุดควบคุมอย่างมีนัยสำคัญทางสถิติที่ระดับ 0.05 ทั้งในด้านความสูง ขนาดเส้นผ่าศูนย์กลาง และจำนวนใบอีกด้วย

CONTENTS

	Page
ACKNOWLEDGEMENTS	iii
ABSTRACT (ENGLISH)	iv
ABSTRACT (THAI)	v
LIST OF TABLES	x
LIST OF FIGURES	xi
CHAPTER I INTRODUCTION	1
1.1 State of problem	1
1.2 Conceptual framework	3
1.3 Objectives	4
1.4 Hypothesis	4
1.5 Scope of study	4
1.6 Expected results	6
CHAPTER II LITERATURE REVIEW	7
2.1 Swine manure	7
2.1.1 Swine manure nutrients	7
2.1.2 The approaches of swine manure utilization	8
2.1.3 Use of swine manure as fertilizer for plants	9
2.1.4 The problems of less use of swine manure in farmers	9
2.2 Centrifuged Residue	10
2.2.1 The characteristics of centrifuged residue	10
2.2.2 The Ratio of Centrifuged Residue Process	11
2.2.3 The Utilization of Centrifuged Residue Approaches	12
2.3 Para rubber tree	12
2.3.1 Botanical characteristics of rubber	12

CONTENTS (cont.)

	Page
2.3.2 The suitable condition for rubber plantation	14
2.3.3 Rubber Variety for Experiment	16
2.3.4 Stumped budding in poly-bag production	18
2.4 Rubber Fertilizer	21
2.5 The Summary of Used fertilizer Formula in the Research	29
2.6 Related researches	29
CHAPTER III RESEARCH METHODOLOGY	33
3.1 Experimental Location and Laboratory	33
3.1.1. Study of Rubber Plant Growth	33
3.1.2. Chemical Analysis of Soil, Centrifuged Residue, Swine Manure and Water	33
3.2 Specimen, Laboratory Tools and Equipment	34
3.3 Research Implementation	34
3.3.1 Centrifuged rubber latex	36
3.3.2 Swine Manure	36
3.3.3 Soil	36
3.3.4 Young Rubber Plant	38
3.3.5 The experiment would be consisted of 4 treatments	38
3.4 Experiment Planning	39
3.5 Statistical Data Analysis	40
CHAPTER IV RESULTS	41
4.1 Properties of Soil, Centrifuged Residue of Rubber Latex and Swine Manure Prior to Experiment	41
4.2 Soil Properties after Experiment	43
4.2.1 pH Value	43

CONTENTS (cont.)

	Page
4.2.2 Electrical conductivity	44
4.2.3 Organic Matter	45
4.2.4 Total Nitrogen	46
4.2.5 Available Phosphorus	47
4.2.6 Exchangeable Potassium	49
4.2.7 Cation exchange capacity (CEC)	50
4.2.8 % B.S.	51
4.3 Nutrient leachate	52
4.3.1 pH	53
4.3.2 Electrical Conductivity	54
4.3.3 Total Nitrogen	56
4.3.4 Available Phosphorus	57
4.3.5 Exchangeable Potassium	58
4.4 Growth Development of Para rubber seedling	59
4.4.1 Height	59
Height Comparison among 4 Treatments	61
4.4.2 Trunk Diameter	63
Comparison of Trunk Diameter among 4 Treatments	65
4.4.4 Leaf Number	67
Comparisons of Number of leaves among 4 Treatments	69

CONTENTS (cont.)

	Page
CHAPTER V CONCLUSIONS AND DISCUSSIONS	71
5.1 Characteristics of soil Centrifuged Residue from Rubber Latex and Swine Manure before Experiment	71
5.2 Soil Characteristics after Experiment	72
5.3 Nutrient leachate	74
5.4 Para rubber seedling growths	75
5.5 Actual Utilization of Blended Fertilizer	76
5.6 Recommendations for future study	78
REFERENCES	79
APPENDICES	84
Appendix A Statistics used in this research	85
Appendix B The 7 th KU-KPS Conference	108
Appendix C Experiment figure	115
BIOGRAPHY	117

LIST OF TABLES

Table	Page
1-1 Parameters and analysis chemical properties of soil, centrifuged residue and swine manure	5
1-2 Parameters and analysis chemical properties of water	5
2-1 The chemical components (%) of swine manure: volume 2,050-2,350 Kg./swine/ year.	8
2-2 The components of natural latex	14
2-3 The Use of fertilizer before tapping	28
3-1 Parameters and chemical properties analysis	36
3-2 Parameters and analysis method of chemical properties of water	39
3-3 Flowchart of experiments	40
4-1 Chemical properties of Centrifuged Residue of Rubber Latex, swine manure and soil before and after experiment	42
4-2 The values of pH	52
4-3 The values of EC	54
4-4 The values of total nitrogen	55
4-5 The values of available phosphorus	56
4-6 The values of exchangeable potassium	57
4-7 Growth of Para rubber seedling	60
4-8 Trunk diameter of Para rubber seedling	64
4-9 The average number of leaves of Para rubber seedling	68

LIST OF FIGURES

Figure	Page
1-1 Conceptual Framework	3
2-1 Centrifuged Residue from Rubber Latex	10
2-2 Dry Rubber Tank Picture before Blended	10
2-3 Centrifuged Residue from Centrifuged Process	11
2-4 Dumped Centrifuged Residue or Pile of Centrifuged Residue at the Factory	11
2-5 Budding RRIM 600 Young Rubbers	16
2-6 Rubber seed RRIM 600	17
2-7 Height Measurement of Poly Bag Rubber from the Crack of Bud to the Tree Top	19
2-8 Stem	20
3-1 Research implementation	35
3-2 Soil Sampling Collection Point	37
4-1 The values of pH	44
4-2 The values of EC	45
4-3 The values of Organic Matter	46
4-4 The values of Total nitrogen	47
4-5 The values of Available phosphorus	48
4-6 The values of exchangeable potassium	49
4-7 The values of CEC	50
4-8 The values of %BS	51
4-9 Height of Para rubber seedling	59
4-10 Trunk Diameter of Para rubber seedling	63
4-11 The average number of leaves of Para rubber seedling	67

CHAPTER I

INTRODUCTION

1.1 State of Problem

Para rubber (Hevea tree), is one of the important economic plants of Thailand, which the totally area of 16.89 million rai has been used for plantation (...Rubber Research Institute of Thailand, 2010). About 2,710,000 tons of Para rubber latex production was recorded as the biggest quantity has been exported in the year 2007 (Rubber Research Institute of Thailand, 2008). Consequently, the large amount fertilizer such as much as nitrogen, phosphorus and potassium were widely used for 0.3, 0.05 and 0.18 kg / plant / year respectively (Rubber Research Institute of Thailand, 2010a), or equivalent to 4.13, 0.689 and 2.48 ton of nitrogen, phosphorus and potassium / year respectively. The study estimated equivalently to 1,178 baht / rai (Potiwadtuthum *et al*, 2010)

Natural rubber originates from Hevea tree and coagulates into a lump at the bottom of the cup, called “cup lump”. In case of making concentrated latex, the collected natural rubber has to add stabilizing agent (ammonia) to prevent the latex from coagulating. If solid rubber is required, all cup lumps, are collected together and processed. For natural latex required by factory, the stabilizing agent added in the latex gathered containers to keep the good quality of production before delivering to the factory for concentrated processing. Chemical substances such as Ammonia, Tetra Methyl Thiuram Disulphide (TMTD), Zinc Oxide (ZnO), Diammonium phosphate (DAP); etc. are added, and then forward to a centrifuge process to remove water and increase the rubber content of the latex. This product called “concentrated of latex”, while the residue in centrifuge machine called “latex residual powder or centrifuged residue”.

The residue, actually average of 10.7 % remaining, (Tekprasit, 1999) is considered as useless material, and mostly remedying as landfill. Several studies reported the value of mentioned residue in the view point of nutrient element as

nitrogen (N), phosphorus (P) and potassium (K) at the average concentration of 2.28 %, 8.54 % and 1.48 % (dry weight), respectively (Tekprasit, 1999). In addition, the study (Ubon *et al*, 2010) of nitrogen, phosphorus and potassium content in concentrated latex sludge was found to be 1.02-2.53 % (N), 22.15-48.19 % (P) and 0.39-0.60 % (K), by dry weight. Moreover, it was remarked that even nutrient elements in residue were as available substances for plant growth enhancement, but there still had some rubber particle remained in the residual and could cause soil problem after use for long time therefore, blended fertilizers was initiated, by blending the small amount of latex residue, to let them functioned at the beginning stage of plant growth enhancement, and addition with the waste of swine manure which normally need time for microorganism to convert the nutrient element into the available organic substance form. In particular, the swine manure report (Mala, 2003) mentioned about the nutrient contents as much as 2.80 % (N), 1.36 % (P) and 1.18 % (K) dry weight, respectively. Therefore, blended fertilizer (latex centrifuged residue and swine manure) was considered to be applied as fertilizer for plant growth enhancement for this study. It was expected that nutrient of centrifuged latex residue while the plant could absorbed. At the beginning stage of growth, swine manure needed some time to be digested as organic fertilizer. This approach could decrease cost of rubber plantation of chemical fertilizer and also latex concentrated waste minimization (Tekprasit, 1999 and Mala, 2003).

So, the objective of this study was to carry out regarding. The effectiveness of blended fertilizer for plant growth enhancement, as well as to study the impacts to soil characteristics, nutrient budget balance, etc.

1.2 Conceptual Framework

Chemical property of soil, centrifuged residue and swine manure before and after experiment were analyzed as designed in Table 1

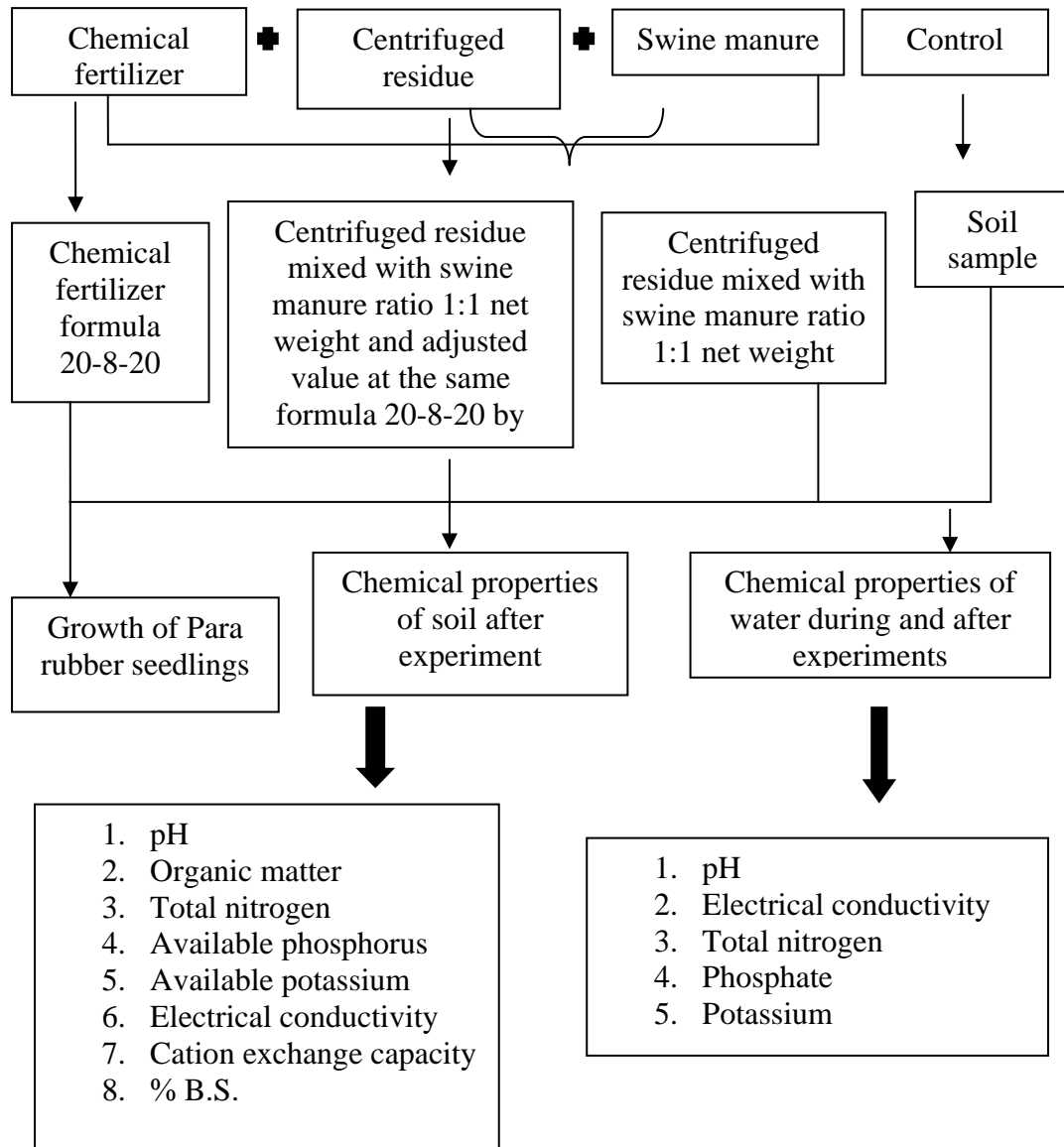


Figure 1-1 Conceptual Framework

1.3 Objectives

1.3.1. To study the nutrient elements of centrifuged residue, swine manure and soil before and after experiment.

1.3.2. To study the growth enhancement of Para rubber seedling according to various fertilizer formula applications.

1.3.3. To study the nutrient leaching out by water during and after experiments.

1.4 Hypothesis

$$H_0 = \mu_1 = \mu_2 = \mu_3 = \mu_4$$

$$H_1 = \mu_1 \neq \mu_2 \neq \mu_3 \neq \mu_4$$

Remark

μ_1 = Treatment 1 was the chemical fertilizer at the concentration of 20-8-20.

μ_2 = Treatment 2 was the mixture of centrifuged residue and swine manure and was adjusted N-P-K fertilizer to have the concentration equivalent to chemical fertilizer 20-8-20.

μ_3 = Treatment 3 was the mixture of the centrifuged residue and swine manure in the proportion of 1:1 by weight.

μ_4 = Treatment 4 was the control treatment.

1.5 Scope of Study

1.5.1 Centrifuged residue from Sri Trang Agro-Industry Public Company Limited and swine manure from rural farm area were studied the physical and chemical properties as soil improvement.

1.5.2 Krabi soil series was used for the experiment (////, 2008) the physical and chemical properties of soil before and after the experiment were studied.

1.5.3 Soil bulk density was analyzed before experiment to study the ratio of fertilizer applications suitable for practice in plantation.

1.5.4 Parameters regarding the characterization of centrifuged residue, swine manure and soil were studied as showed in Table 1-1

Table1-1: Parameters and analysis methodology chemical properties of soil, centrifuged residue and swine manure.

Parameters	Analysis method
1. pH	pH meter, Land Development Department(LDD), 2001
2. Quantity of organic materials	Walkley and Black, (LDD, 2001)
3. Total Nitrogen	Kjeldahl system. (LDD, 2001)
4. Available Phosphorus	Bray-II, (LDD, 2001)
5. Available Potassium	Flame photometer, (LDD, 2001)
6. Electrical conductivity	Conductivity meter, (LDD, 2001)
7. Cation exchange capacity	Ammonium acetate, (LDD, 2001)
8. % B.S	$\sum (\text{Exch.cation} / \text{CEC}) \times 100$, (LDD, 2001)

1.5.5 Chemical properties of leached water were analyzed every 15 days as parameters presented in Table 1-2.

Table 1-2: Parameters and analysis methodology of the chemical properties of leached water.

Parameters	Analysis method
1. pH	pH meter (Department of Environmental Quality Promotion (DEQP),2006)
2. Electrical conductivity	Conductivity meter (DEQP, 2006)
3. TKN	Nesslerization Method (DEQP, 2006)
4. Phosphate	Ascorbic Acid Method (DEQP, 2006)
5. Potassium	Flame photometer (DEQP, 2006)

1.5.6 Para rubber seedlings RRIM 600 variety aged 2 months were used for the experiment. Growth of Para rubber seedlings were measured 3 cm. above bud-grafted for height (cm.), Trunk diameter (mm.) and number of leaves were also studied for every 15 days.

1.6 Expected Results

1.6.1 Knowledge gained about nutrient elements of centrifuged residue and swine manure.

1.6.2 Knowledge gained about soil properties before and after treated with blended fertilizer for Para rubber seedling plant.

1.6.3 Knowledge gained about Para rubber seedling growth after treated with blended fertilizer at various designed formula.

CHAPTER II

LITERATURE REVIEW

To study on the Utilization of Blended Fertilizer of the Centrifuged residue from Para rubber latex and swine manure as growth enhancement for Para rubber seedling, documents and related researches were reviewed the research process consisted of 6 items as follows:

- 2.1 Swine manure
- 2.2 Centrifuged residue
- 2.3 Para rubber seedling
- 2.4 Para rubber fertilizer
- 2.5 The summary of fertilizer formula applied to the research
- 2.6 Related researches

2.1 Swine manure

The mixture of swine manure consisted of indigestible refuse such as solid mass, fiber, digestible parts but in absorb and feces, especially from alimentary canal such as intestinal lining, mucous membranes, nutrients, bacteria, and by-product of bacteria (Sasangta, 2000).

2.1.1 Swine manure nutrients

The quantity of nutrients in swine manure was studied by several agencies. Department of Agriculture (1997) referred by (Rutthanalum, 2008) analyzed the chemical components of swine manure as detail shown in Table 2-1.

Table 2-1 The Percentages Chemical Components of Swine Manure (Volume 2,050-2,350 Kg./swine/ year)

Types	Moisture	Organic Matter	Total Nitrogen	Phosphorus	Potassium
Manure	82.0%	16.0%	0.6%	0.5%	0.4%
Urine	94.0%	2.5%	0.4%	0.05%	1.0%

Source: Department of Agriculture, 1997 referred by (Rutthanalum, 2008)

The average values of swine manure nutrients were N (2.80 %), P (1.36 %) and K (1.18 %) (4) and N (1.3 %), P (2.4 %) and K (1.0 %) respectively (Rubber Research Institute of Thailand, 2007).

2.1.2 The approaches of swine manure utilization

Important minerals in swine manure are N, P and K, which can be used in many ways:

1. Fertilizer: Swine manure can be used to produce fertilizer to enhance soil physical quality and as the source of nutrients for plants. At the first period, the microbes decompose the manure and the plant can then utilize it.
2. Animal feeds: Swine manure can be mixed with other feeds. However it must be safe from any diseases contamination, which can cause danger to animal, and food quality reduction.
3. Fishery feeds: Through building pig sty over fish pond. When the pigs defecate, the manure directly drops down to the fish pond or use the swine manure from another places as fishery feeds.
4. Worm culture: Swine manure can be used as whorl maggot breeding as an alternative source of protein for many pet food formulas.
5. Alternative energy: Fermented swine manure and waste water in the anaerobic condition causes biogas which can be used as another alternative energy such as fuel for the lamp or electricity. The fermented swine manure is able to be used as fertilizer for plants (Pollution Control Department, 2008).

2.1.3 Use of swine manure as fertilizer for plants

1. The use of dried swine manure fertilizer for agriculture should be applied before cultivation. Soil tillage should be done with organic fertilizer at the ratio 1-2 ton/ rai.

2. The use of swine manure in horticulture: soil should be prepared by mixing with fertilizer. The ratio is combination of loamy soil: swine manure (1:1) and clay: swine manure (1:2). Sand and clay, firstly, mix together in 1:1; then, the mixed sand mixes with swine manure (1:1). For perennial tree, 20-50 Kg./ plant is needed at the bottom of exeavated pit and around bushes every year.

3. To use swine manure fertilizer in vegetable cultivation, it is suggested that the fertilizer should be well decomposed fertilizer and it is recommended to use as 1 Kg. / 1 m² area.

Raising one pig within a year can acquire fresh swine manure for 1-2 rai of cassava cultivating and for 1-3 rai of vegetable cultivating, cabbage, onion, garlic and tomato.

2.1.4 The problems of less use of swine manure by farmers

1. The amount of swine manure is insufficient because it contains less nutrients white the amount of usage is high.

2. Strong odor of swine manure can disturb people in the community so it is not convenient to use.

3. The cost of labor and transportation of swine manure to the cultivation area are high (Rutthanalum, 2008).

2.2 Centrifuged Residue



Figure 2-1 Centrifuged Residue from Para rubber latex

2.2.1 The characteristics of centrifuged residue

The characteristics of centrifuged residue are mire and white or light yellow color; moreover, it is considered as solid waste in composition of contamination as dust, bark, remnants of leaves and sand together with Mg and P as important components. It derives from the sedimentation in clarifier as Figure 2-2 and from the latex centrifuged process as Figure 2-3. Moreover, the Para rubber latex factory, at the present time, does inappropriate management such as dumping centrifuged residue as solid waste for land reclamation. In fact, the component of centrifuged residue is N, P and K that average equaled to 2.28, 8.54 and 1.48% of dry weight, respectively and the pH value is equal to 9.0 ± 0.1 which is necessary for plants growth (Tekprasit, 1999 and Department of Industrial Works, 2007).



Figure 2-2 Dry Para rubber tank picture before Blended



Figure 2-3 Centrifuged Residue from Centrifuged Process

2.2.2 Ratio of Centrifuged Residue Process

At the Para rubber latex factory, centrifuged residue has been found between 0.7-500 ton/month or the proportion of centrifuged residue is 0.6-50 Kg. / 1 ton of rubber latex of which the production can produce waste around 1% of the rubber's weight. From the research, it was found that each factory used latex to produce rubber latex around 39.91-157.56 ton/day. Therefore, it could be calculated waste in the form of centrifuged residue from each latex factory about 0.39-1.58 ton/day (Takprasit, 1999). Centrifuged residue was considered as waste with high humidity. Practically, the factory dumped it as wastes or for landfill. At the present, some factories use it as fertilizer in oil palm plantation.



Figure 2-4 Dumped Centrifuged Residue or Pile of Centrifuged Residue within the Factory

2.2.3 Utilization of Centrifuged Residue Approaches

General centrifuged residue is solid waste within highly humid. Practically, the factories dump it as wastes, as landfill materials and some use it as fertilizer in oil palm plantation. Although centrifuged residue contains useful nutrients for plants, the research on utilization of centrifuged residue as fertilizer is rarely found. However, centrifuged residue itself is contaminated with latex scraps which might affect to the soil quality in long term.

2.3 Para rubber tree

The Para rubber tree is an important industrial crop. At the moment, Thailand is the first Para rubber producer in the world, Indonesia and Malaysia is the second and the third, respectively (////, 2008).

The Para rubber plantation area in Thailand, now, scatters through out the country. Regarding the information from Rubber Research Institution, it mentioned that the total area of Para rubber plantation in Thailand was around 13.78 million rai; moreover, the greatest Para rubber plantation was in the South of Thailand about 10.95 million rai, especially in Suratthani Province was about 1.81 rai. Furthermore, the government, at present, supports the farmers to plant Para rubber plantation through expanding to the Northeast and the North departs of Thailand (Rubber Research Institute of Thailand, 2008).

2.3.1 Botanical characteristics of Para rubber

Root is the primary root system which has both primary root and secondary root to find food and hold stem. Generally, the depth of the rubber's root is about 1-2 m. but the root will be deeper than 2 m. if the soil quality is nice loose; at the same time, there is secondary root in order to find food around the surface.

Stem is a cone-shape like when planted by seed and it looks like tube when it does propagation by grafting which is composed of 3 parts:

1. Wood

It is soft wood which has white and yellow color in core of the stem.

2. Tissue

It is thin tissue around the wood.

3. Bark

This outer part is next to the tissue which prevents danger from outside. Inside bark connects to the tissue which has latex tubes the most.

Leaves, in general, are compound leaves, 1 leaf stalk has 3 sub-leaf stalks. Each leaf is around 10-20 cm. long and the leaf arrangement is spiral pattern. Its duty is to cook, breath and emit. The rubber's leaf sprout up layers called "*Chatra*". The tree will shed leaves during dry season, except the rubber under 3 years old, and each species has different characteristics.

Flower blooms after rubber trees shed leaves by the end of stem. Its shape is bouquet with male and female flowers in the same inflorescences which can breed open-pollination. Naturally, flowering is during February-June and the second is during August-October. The first flowering can produce more fruits and seeds than the second.

Fruit is like section and normally has 3 sections. Each section has small seed inside. It is green color when it ripens, the color will change to brown and hard. The diameter of ripe fruit is around 4.5-5.0 cm. and the height is about 4.5 cm. One rubber tree provides 50 fruits/ years in average.

Seed is brown color with white stripe. The length is 2-2.5 cm. and the width is around 1.5-2.5 cm. together with its weight is around 3-6 Kg. The rubber seed will sprout approximately 20 days.

Latex vessel looks like tube around the rubber stem from the lower left to the upper right, excepting KRS 13 species whose latex tube characteristic is like clockwise. Normally, it is vertical around 25°. The most density of latex vessel is around the tissue and it gradually reduces around hard bark zone (Rubber Research Institute of Thailand, 2007b and Wansiri, 2006).

Latex is suspension which is white or cream liquid. The density is 0.975-0.980 g/ml. The pH is around 6.5-7.0 and the viscosity is ambiguous due to many factors such as rubber species, age of rubber, system and the process of rubber tapping and season.

Table 2-2: The Components of Natural Latex

Components	% by weight
Substance that is solid	36
Dry rubber content	33
Protein	1 – 1.5
Resin	1 – 2.5
Ash	Reach to 1
Sugar	1
Water...Blended with other substances	...100

Source: Kajornchaiyakul, 2006

2.3.2 Suitable condition for Para rubber plantation

The rubber can grow very well in these conditions as follows:

1. Rubber plantation area the elevation should not be above 600 MSL. In general, the rubber should plant in the plain area or the area elevation with around 200 MSL. Moreover, the slope is lower than 35° and if the slope is higher than 40°, it is necessary to plant in terraces system.

2. Soil the rubber tree can grow very well in the infertile soil. The soil quality characteristic is different depending on parent material (Keawruenrom, 2004). The depth of the land surface should not be lower than 1m. without bedrock or subsoil layer, this can obstruct root growth. Moreover, the soil should not be alkaline soil and has the pH 4.0-5.5 as well as the groundwater should be deeper than 1 m. The soil texture should be loam, clay loam or sandy clay loam and the fertility is in moderate level and well ventilates and should not be stagnant. Therefore, soil is the influenced factor on rubber plantation enhancing early tapping with high yield. Therefore, soil is radically basic factor for rubber production including adding fertilizer, vegetative cover and appropriate soil management.

The soil group for planting rubber is classified into 2 groups: **clay loam group** such as Chumphon series, Pathiu series, Ao Luek series, Krabi series, Thai Muang series and Lamphura series found at the previous rubber plantation area; and Kabin Buri series, Chokchai series and Pak Chong series found at the new rubber plantation area; while **sandy loam** such as Khlong Thom series, Kho Hong

series, Na Thawi series, Khuan Ka Long series, Tha Sae series, Nam Krachai series, Sadao series found at the previous rubber plantation area; as well as Korat series, Warin series, Satuk series and Yasothon series these soil series have been found suitable as new rubber plantation area (Rubber Research Institute of Thailand, 2007a).

For this study, the Krabi series was selected for the experiment since it is very deep silty clay loam. Top soil is loam and clay loam with well ventilation. The pH is 4.5-5.5 which is suitable for rubber tree and other perennial trees.

3. Soil organic matter soil for planting rubber trees, in general, has low organic matter so the amount of soil organic matter essentially increases through vegetative cover (fabaceae family) between the rubber tree lines due to the fact that the amount of soil organic matter decomposes and gradually changes and vanishes. In case of soil erosion or soil runoff (Kangpidsadarn, 2007a) and lost soil organic matter, to restore the amount of soil organic matter is difficult and takes time; therefore, the best protection is to prevent soil erosion and the land should not be deserted.

4. Rainfall the volume of rainfall should not be less than 1,350 ml./ year and it should not rain less than 120 days/year.

5. Relative Humidity is the important factor for planting rubber. The change of relative humidity depends on the volume and rainfall distribution. In fact, the rubber can grow well at the place that has the relative humidity between 65-90 %. The area having high relative humidity can plant rubber tree very well and high production but it is easy to cause epidemic.

6. Temperature should be around 24-27 celsius in average

7. Wind speed should not over 1 m. / second in average which is suitable for rubber growing. The average of wind speed is 2.0-2.9 m. / second which obstructs the growth of rubber and latex circulation. The wind speed over 3 m. / second restrains the growth of rubber tree and severe affected latex circulation.

8. Light distance the requested light distance is between 1,800-2,800 hour/year but the light distance per day does not impact on rubber plantation (Rubber Research Institute of Thailand, 2007b; Sangvatin, 2008 and Suchard, 2005).

9. Light intensity the rubber sprout needs the light intensity around 60-70 %.

2.3.3 Rubber Variety for Experiment



Figure 2-5 Budding RRIM 600 Para rubber (seedlings)

The RRIM 600 variety age two months was selected for the experiment. The prompt stumped budding was the breeding between Tjir varieties with PB 86 variety from Malaysia which has the identity as follows:

Leaf storey

The characteristic of leaf storey is a cone shape, the position of lamina is opened, leaf storey is small and its width is narrow and the composed of a relative number of leaves is sparse.

Leaf

The leaf color is yellowish green. The vivid color of midrib is yellowish green and the based leaf is acuminate. The apex is apiculate. Blade (lamina) is flat with pinately parallel venation. The shape of middle leaflet with plamately parallel venation is straight, obovate, entire, flat and shiny.

Petiole

The petiole is straight and moderate length. Leave scar is cordate. The inner part of sub-petiole is moderate length.

Auxiliary bud

The auxiliary bud is less bulging and is at the base of petiole. It sticks inside the stem.

Stem

The shape of stem is straight and its color and limb is dark color.

Crown

It is moderate crown which looks like fan and its density is ordinary.

Branches

Having low branching, the tree limb is rather long and acute angle with moderate size and extreme branch bending.

Seed

It is medium size and square shape. The head, the bottom and the back is entire and the external part is ridge together with there is the eruption on the skin.



Figure 2-6 Para rubber seed RRIM 600 variety.

The advantages and disadvantages of RRIM 600 variety are as follows:

Advantages

- This rubber regularly provides a lot of latex
- The growth rate is found favorable during rubber tapping
- Tapping panel dryness rarely occurs

Disadvantages

- It cannot be tolerate to Pink Disease, Phytophthora Leaf Fall and Black Stripe
- It is not suitable for planting at the shallow soil and at the high level of groundwater (Sangvatin, 2008)

2.3.4 Para rubber seedling in nursery bag

Para rubber seedling meant the good quality bud-grafted seedling maintained in polyester bag until the rubber has 1 leaf storey which was good quality according to the standard of Department of Agriculture (Rubber Research Institute of Thailand).

Para rubber seedling in nursery bag meant material used for maintaining scion rubber until its leaves or called leaf storey sprouted up at least 1 leaf storey and could cultivate in the plantation area (Sangvatin, 2008).

Para rubber seedling in nursery bag meant the material used bud-grated seedling to be planted in the polyester bag around 2-3 months until the size of seedling shown 2-3 leaf stories which was ready to be planted in the plantation area. The size of nursery bag was black color about 11x35 cm. making reams around 3 mm. 3 lines and each line was around 5-7 reams (Office of the Rubber Replanting Aid Fund).

The standard of Para rubber seedling has the quality as follows:

- The size of bag is at least 11x35 cm. and the bag is reamed in order to drain the water.
- The soil characteristic is rather clay to prevent broken bag during transportation.
- The amount of soil should be higher than 25 cm. from the bag edge and the bag should not have weed.

- The bud-grafted seedling in polyester bag should be qualified according to the standard set by the Department of Agriculture and the scion variety should meet the specification of Department of Agriculture.
- The scion rubber should be disease-free, including leaf, stem and root and the growth of rubber should have at least 1 leaf storey and not over 2 leaf stories.
- The seedling should have leaf story and the height of rubber from the bud-grafted mark to the top of the leaf is not over 20 cm. (Rubber Research Institute of Thailand) as shown in Figure 2-4.

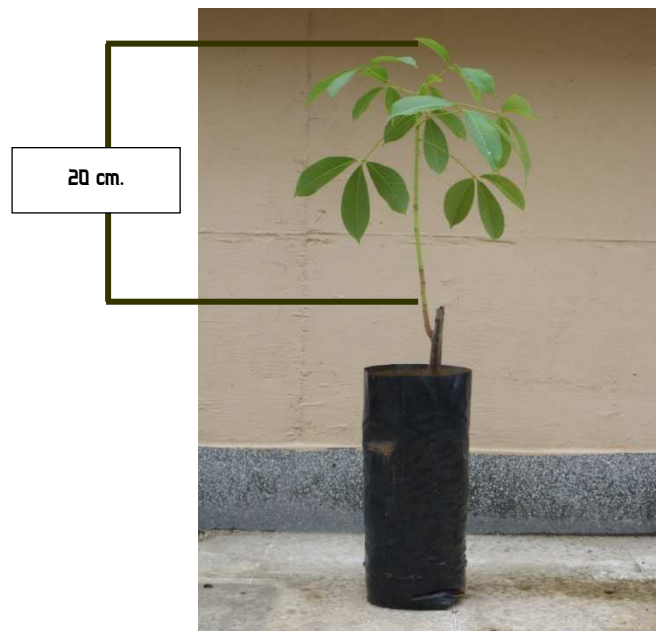


Figure 2-7 Height Measurement of Para rubber seedling in nursery bag from the bud to the tree top

The bud-grafted Para rubber seedling in polyester bag is popular and suitable for rubber plantation and for plant repair because plant growth would be regularly uniformed and needed very few fixing for dead seedlings. The material used for seedling such as

- Plastic bag should be black color size 11x35 cm. and be approximately reamed for the whole bag.

- Soil texture for seedling should be rather clay, it was suggested to apply by soil mixed with organic matter (manure or compost) as 2:1 plus rock phosphate fertilizer 10 g./ pack.
- Based-seedling stem (Para rubber seedling) is the local variety which is easy to bark, age from $4\frac{1}{2}$ till 8 months. The stem dimension is about 1.0-1.2 cm. The height from the ground is 10 cm. The local rubber seedling from natural seed breeding such as RRIM 600, BPM 1, and RRIT 214. The primary root system is strong and had highly disease resistance but it has low latex production.



Figure 2-8 Based-seedling stem

Source: Rubber Research Institute of Thailand, 2007c

The standards of based rubber seedling stem used for making seedling in nursery bag are as follows.

- The single primary root is straight and undamaged root coat.
- The length of root from base is not less than 20 cm.
- The scion dimension is between 0.9-2.5 cm.
- The length stem from soil cone to the scion is not over 10 cm. and the scion until stem indentation is not less than 8 cm.
- The width of green budding is not less than 0.9 cm. The scion condition should well attach the stem without yellow color or dryness. The scion position should not be upside down and should use scion petiole.

- The scion stem should be fresh without disease and weed (Rubber Research Institute of Thailand, 2007c).

Planting Para rubber seedling in the nursery bag

This method is popular and the most successful comparing with other planting method because the survival rate is high and steady growth; moreover, this method shorten the duration of seedling planting after care and the rubber could be tapped faster. However, the seedling in nursery bag is expensive and needed delicately careful during transportation because if the bag is broken, the chance of rubber seedling to survive was also low. This method should plant during rainy season. The first step is to dig the pit and prepare the seedling rubber into the excavated pit by placing the joint part between root and the scion being the same level of the pit edge, cut off the bottom of the bag around 2-3 cm. in order to cut the distorted part of the root. Placing the rubber seedling into the pit, with adjusted the root and the scion, cut the plastic bag vertically ready for removing then put soil around the stem. It was suggested that soil should be a little bit higher than the surrounding area in order to prevent the stagnant water. Than softly removing the plastic bag off and put the stick beside the new planted. Before dry season, the tree should be covered with dry leaves radius of 50-80 cm. and be far from the rubber trees around 5-10 cm. (Sangvatin, 2008).

The growths of rubber sprout

After the rubber seedlings are planted, the leaf storey later appears in 2-6 weeks per 1 leaf storey; however, it depends on the environment and the rubber sprout maintenance (Rubber Research Institute of Thailand, 2007c).

2.4 Rubber Fertilizer

The fertilizer is important for the growth and production. Due to the rubber infertile area for plantation and some areas have been planted rubber trees for long time resulting in soil erosion and natural decomposition of soil organic matter, some nutrients lost during rubber tapping. If the rubber trees could not get enough fertilizer, it might affect to the growth and production.

The rubber trees in different ages require different amount of nutrition which showed the nutrient requirement in each ages through (Kangpidsadarn, 2007b). The nutrition, which rubber trees require, is N, P and K called macronutrient elements and the secondary nutrient is called micronutrients such as Ca, Mg and S and the nutrient supplement less requires such as Zn, Cu, Fe, Mn, B, Mo and Cl. While the plant gets C, H and O₂ from water and air (Wansiri, 2006).

The various nutrients, which is important for growing rubber as mentioned above, have roles and importance as follows:

1. Nitrogen (N)

The role of N helps the rubber tree growing and producing latex. The rubber trees require N a lot which is around 3-4% of dry leaf weight (Sangvatin, 2008); but in general, the soil in Thailand has low nitrogen because the farmers use the fertilizer which has low nitrogen and low soil organic matter. Therefore, the Nitrogen should be added by various methods; for example, planting vegetative cover, Fabaceae family, among the young rubber trees lines affects to the maintaining level of nutrition, especially Nitrogen level, and adding Nitrogen for rubber trees. If the rubber trees lack of Nitrogen, the stem becomes small and bark color is dry and harder than normal; thus, it is difficult to tap. The leaf is yellowish green and smaller than normal and has a few. If it is severe condition, it will show in the first leaf storey (Kangpidsadarn, 2007a).

Moreover, the fertilizer effects on the growth and the production of rubber. There are other related factors to the growth and rubber production as well. From the report (Dea *et al*, 2001), it mentioned that, likewise, the different type of soil influences on the growth and the production.

2. Phosphorous (P)

P is important in terms of cell division and building cell in plant. It helps the root growing which helps root for more K absorption. Normally, the acid soil has iron and aluminum. P is in form ferric Phosphate and Aluminum Phosphate which plant cannot use its benefits. Therefore, the soil for planting rubber trees has low available Phosphorus. The rubber trees, which lack of phosphorus, stop growing. The

stem and leaf is violet and the latex is less but if the soil has a lot of Phosphorus, the rubber trees will produce less latex.

3. Potassium (K)

Potassium is the important component of enzyme which is for synthesis and for producing protein and starch; additionally, it conveys starch and glucose and controls pH balance as well as opened-closed leaf; besides, it helps the tree and root system tolerating insects and weeds together with increases production and quality. It means that if the rubber trees receive enough Potassium, the bark will grow faster and the volume of latex will increase. In other words, if the rubber trees receive less Potassium, the bark will grow slower; the latex quality will decrease; the stem is small and pale green; the apex gets dry and has brown dots and some found red dots or brown dots between venation of young leaves (interveinal chlorosis).

4. Calcium (Ca)

Calcium is important for cell division and for cell wall and helps the root to grow. Ca can reduce toxic of aluminum which is high in acid soil. Therefore, it increases the benefits of Phosphorus and Potassium. To put Iron Phosphate increases the advantage of calcium in soil as well as calcium in the rubber leaf due to the fact that iron phosphate has Ca around 30 % of weight. The rubber trees can adjust its elves in the low calcium condition so lacking of calcium cannot find in the soil for planting rubber.

5. Magnesium (Mg)

Mg is important micronutrient which is influenced on the growth and on increasing rubber production because Mg is the component of chlorophyll used for photosynthesis. Even adding Mg reduces a number of leaves, it increases production because the rubber trees vastly produce; the nutrient in the leaves is used for producing latex. Lacking of Mg in the rubber trees has less latex. The apex and the area between venation obviously exhibit yellow color but venation is still green color. The source of

Mg is such as Mg fertilizer in form of Magnesium sulfate or Kieserite (26 %) and dolomite.

6. Iron (Fe)

Fe is important to synthesis of chlorophyll but it is not the component of molecule of chlorophyll. Fe dissolves well in acid soil but the soil, which has high Phosphate, lacks of Fe because Fe reacts with P so the sediment is disadvantage. To add N, P, K and Mg to rubber trees for a long time makes the rubber trees being difficult to absorb and the entire leaf becomes yellow.

7. Manganese (Mn)

The role of Mn has various reactions with plant such as oxidation and reduction which is the component of some enzyme related to plant respiration. The enzyme stimulates the utilization of N and producing chlorophyll. The soil for planting rubber has high amount of P will lack of Mn because Mn reacts with P causing disadvantage sediment. If the rubber lacks of Mn, its symptom is like lacking of Fe: the leaf is pale yellow. Fe and Mn are antagonist each other. If there is a lot of Mn, the rubber will absorb less Fe.

8. Zinc (Zn)

This mineral is related to metabolism of Auxin which controls the growth of rubber tree. Zn, which is advantage to rubber trees, should be able to dissolve in water so the root can absorb. The benefit of Zn reduces when pH increases. Lacking of Zn happens when the soil has a lot of P and Cl. This makes Zn reaction with P becoming insoluble compound. If rubber lacks of Zn, it stops growth, the latex decreases, the leaf becomes small and the root has wrong feature.

9. Copper (Cu)

Copper produces Lignin which is the component of Ascorbic acid Oxides (enzyme) enhancing rubber tree growth. If the rubber severely lacks of Cu, it dies

back in the soil having high organic matter such as peat soil. Cu will be fixed with organic matters which cause indigestible form of Cu.

10. Boron (B)

Boron is important to produce cell, cell division and cell enlargement of rubber tree. This chemical is related to the plant physiology process such as metabolism. Boron is essential for rubber because it is immobile from old leaf to young shoot. In case of Boron deficiency, the leaves stop growing and its shape is eccentric; moreover, if it severely lacks of mineral, the young shoot may die.

11. Molybdenum (Mo)

The function of this mineral is to produce protein. This mineral is different from other minerals because the advantage of Molybdenum will increase when the pH is high. Indicating low pH level, pH level of rubber soil is ranging about 4.0 - 5.5. If the rubber lacks of this mineral, the latex decrease (Kangpidsadarn, 2007a).

2.4.1 Used fertilizer in Para rubber plantation areas is divided into 4 types

- Type 1 fertilizer used for sprout plot
- Type 2 fertilizer used for grafting plot
- Type 3 fertilizer used before tapping
- Type 4 fertilizer used after tapping

Type 1: Fertilizer used for sprout plot fertilizer applied for this plantation has, 2 types

Type 1 Fertilizer plant foundation, P (0-3-0) at the ratio of 150 Kg./ rai gradually spreads through out the prepared plantation area. The prepared soil should be moderate fertile loam; in case of sand soil, manure or organic fertilizer should be added during soil preparing around 1 ton/rai.

Type 2 Enrichment fertilizer should be added after planting for plant enrichment. For old rubber plantation, the fertilizer ratio 20-8-20 of 40 Kg/ rai and the

ratio 20-8-20 of 60 Kg./ rai applied for loamy clay and sandy loam plantation, respectively. On the other hand, the fertilizer ratio 20-10-12 of 30 Kg./ rai suitably new rubber plantation areas.

Precautions in using manure as fertilizer

- Stop putting fertilizer for 1 month before grafting because it could make grafting be rotten.
- Should not put fertilizer close to the stem or rubber leaves because they might be burned. For the rubber sprout aging 1-2 months, fertilizer should widely spread around 5 cm. and for the rubber sprout aging 3 months and before grafting for 1 month, fertilizer should gradually spread around the stem (Surat *et al*, 2010 referenced in (Osotspa)).
- Fertilizer should be added when the 1st leaf storey turned to be and should not put during shoot leaf.

Type 2: Fertilizer used for grafting plot

Fertilizer for grafting plot supported the more success healthy seedling resulting in more seedling quantity gained. For old plantation with loamy clay, the fertilizer ratio 20-8-20 for 35 Kg./ rai and for sandy loam, the ratio is 20-8-20 for 50 Kg./ rai. The fertilizer is ratio 20-10-12 for 30 Kg./ rai is used for new rubber plantation and for all types of soil.

After grafted and truncated leaves, fertilizer should be added to enrich graft. The ratio of fertilizer is 120 Kg./ rai used for the first year in the loamy clay or 180 Kg./ rai used for sandy loam; besides, the fertilizer in ratio of 90 Kg./ rai is used for new rubber plantation by separating into 3 times, after cutting the stem by 2 months, 4 months and 6 months respectively. after cutting watersprout (*King Kra Dong*) fertilizer 160 Kg./ rai is used for loamy clay, fertilizer for 240 Kg./ rai used for sandy loam or 120 Kg./ rai for the new rubber plantation area by separating in to 4 times.

Type 3: Fertilizer used before tapping

This type of fertilizer is used since rubber tree has been planted until tapped such as fertilizer for ground-based bottom and fertilizer for enrichment.

- **Ground-based bottom fertilizer** is essential for root growth acceleration. Thus, rock Phosphorus fertilizer (0-3-0) has 25% of total Phosphorus and 3% available Phosphorous is recommended for its step of plantation. The method of using this fertilizer is to excavate the soil into 2 parts: the upper layer and the lower layer. The upper soil put back into the excavated pit, the lower soil mixed with rock Phosphate fertilizer in ratio of 170 g./ pit.
- **Enrichment fertilizer** is for the growth acceleration of rubber tree and could be tapped faster including to increase its production. There are 2 formulas as follows:

Formula 1: 20-8-20 for all types of soil at the old rubber plantation areas

Formula 2: 20-10-12 for all types of soil at the new rubber plantation areas

The formula for the old rubber plantation areas has different ratio depending on types of soil texture. The formula of the new rubber plantation areas is similar with all types of soil as detail in Table 2-3.

Table 2-3: The amount of fertilizer utilization before Tapping

Year	Rubber sprout aging (Month)	Old rubber plantation		New rubber plantation	
		Chemical fertilizer 20-8-20(g/tree)		Chemical fertilizer 20-10-12 (g/tree)	Organic fertilizer (kg/tree)
		Loamy clay	Sandy loam	All kinds of soil	All kinds of soil
1	2	70	100	60	1
	5	100	140	80	-
	11	130	170	100	-
2	14	150	200	110	2
	16	150	210	110	-
	23	150	210	120	-
3	28	230	320	180	2
	36	230	320	180	-
4	40	240	330	180	2
	47	240	330	180	-
5	52	260	360	200	2
	59	260	360	200	-
6	64	270	370	200	2
	71	270	370	200	-

Source: Kangpidsadarn, 2007a

Type 4: Fertilizer used after tapping

After tapped rubber trees, it is necessary to add fertilization every year in order to promote regularly increase the production. The amount of appropriated nutrition after tapped rubber trees is fertilizer formula 30-5-18 which is suitable for all types of soil, both old and new rubber plantation areas through putting fertilizer in ratio of 1 Kg./ tree/ year and separating into 2 times per year with 500 g./ tree for each time. The fertilizer firstly put in the rainy season after shed leaves, while leaves semi-

young to semi adult, around the end of April to May. The second time is around August to September by sowing fertilizer far from the stem around 3 m. or from the middle of rubber line and concealed it at the sub-surface building around 5-10 cm.

The soil, which lacks of Mg should, add Kiesirte (26 % MgO) 80 g/tree/year. The rubber plantation with vegetative cover regularly put fertilizer during rubber lines. During the first 2 year of tapping, the fertilizer is unnecessary in case of fertile soil and sufficient nutrient of rubber leaves because the fertilizer, in fact, is put during sprout still enough at the first tapping; besides, it is unnecessary to add fertilizer after tapped since the remaining vegetative cover, branch remnants, dry leaves and have piled up for many years and when they are decomposed, they naturally turn in to organic matter (Kangpidsadarn, 2007a).

2.5 The Summary of Used fertilizer Formula for this Research

The rubber fertilizer formula before tapping used in this research was 20-8-20 in ratio of 5 g./ tree, which was suitable for 2 months Para rubber seedling experimented planting in polyester nursery bag. Krabi soil series: Kbi was selected for the experiment because its characteristic is very deep silty clay loam. The top soil is loam till loamy clay, well drainage and the pH is 4.5-5.5 that is appropriated for planting rubber trees and other perennial trees.

2.6 Related researches

The study of the liquid fertilizer preparation from Centrifuged Residue of Rubber Latex (CRRL) by of Saowanee (2007) found the average mineral quantity of centrifuged residue of N, P (in form of P205), K (in form of K20), Mg, Zn and Ca as 3.31 %, 14.69 %, 1.01%, 12.24 %, 0.63% and 0.03%, respectively. Centrifuged residue was their distilled by distilled water, it was found that Mg was dissolved the most around 3.90% by weight followed by N, K, Zn, and Ca, the average quantities were 0.26 %, 0.25%, 0.16%, 0.08% and 0.01%, respectively.

The study of the centrifuged residue characteristic and its ratio from latex industry by Warasri (1999), it presented that the producing latex process created the centrifuged residue in average of 10.7 kg. / ton of latex. At the present, the factory disposed by dumping as landfill which was inappropriate practice. Regarding the chemical properties analysis it was found that the average amount of N, P and K was equivalent to 2.28%, 8.54% and 1.48% of dry weight, respectively. Therefore, it was tested with Manila grass and results good showed growth rate. However, the centrifuged residue contaminated with Zn and small latex remained. Such latex in the centrifuged residue could change the soil quality in long term if the centrifuged residue was used a lot because the latex was rather difficult to decompose and block top soil; thus, water absorption capability of soil was lessen.

The study of the utilization of centrifuged residue from latex industry together with the sediment from water treatment of frozen chicken factory in form of soil enrichment by Walaiporn (2004) the study was conducted the experiment with 3 kinds of plant, lettuce, tomato and rice. It was found these 3 plants did not show any sign regarding lack of nutrient and production by dry weight and was not different from using chemical fertilizer.

The study of the utilization of chemical fertilizer and farm manure by of Evanylo *et al* (2008) the study was conducted the experiment on maize, pumpkin and pepper plantation. The findings were that at the initial stage, the plot with chemical fertilizer exhibited more plant growth than those cultivated by farm manure. Later, physical properties of soil with farm manure were more fertile than the plot used chemical fertilizer.

The study of using organic fertilizer with chemical fertilizer towards the growth of rubber sprout in region 1 by Suwanmongkorn *et al* (1998) the experiment was conducted 3 times by employing 4x4 Factorial in RCB. The rate of chemical fertilizer was 50%, 75% and 100% by weight and without fertilizer; consequently. The results showed that the rubber trees with fertilizer significantly had better growth rate than without fertilizer. The 4 organic fertilizer applications, they

were without fertilizer and the fertilizer using rates of 100%, 200%, and 300% by weight, it was found that the different rate of organic fertilizer using did not have any affect to the plant growth significantly. The researcher, however, could not summarize that the use of organic fertilizer did not affect the growth of young rubber due to the fact that the amount of organic fertilizer probably was not sufficient for the rubber growth.

Effects of Organic Manure Application with Chemical Fertilizers on Nutrient Absorption and Yield of Rice in Hunan of Southern China by Xu *et al* (2008) this research conducted four different treatments: treatment 1, no nitrogen with chemical P and K (PK); treatment 2, swine manure only (M); treatment 3, N, P and K chemical fertilizers only (NPK) and treatment 4, half chemical fertilizers combined with half swine manure (NPKM). The results showed that organic manure application with chemical fertilizers (NPKM) increased the yield and Nitrogen use efficiency of rice, reduced the risk of environmental pollution and improved soil fertility greatly. It could be a good practical technique that protected the environment and raised the rice yield in this region.

Effects of long-term chemical fertilization and organic amendments on dynamics of soil organic C and total N in paddy soil derived from barren land in subtropical China by Li *et al* (2010) this research conducted five different treatments: treatment 1, chemical fertilizers (NPK); treatment 2, chemical fertilizers and rice straw (NPKRS); treatment 3, chemical fertilizers and double amounts of rice straw (NPK2RS); treatment 4, chemical fertilizers and swine manure (NPKPM) and treatment 5, chemical fertilizers and green manure. The results showed that rice yield was higher in treatments of organic amendments (NPKRS, NPK2RS, NPKPG and NPKGM) than in chemical fertilization only. This study indicated application of chemical and organic fertilizers sustained relatively high rice productivity. After rice cultivation, SOC and total N increased linearly with cultivation years, and accumulated only in surface layer steadily but slowly.

Chemical degradation of a Ferralsol (Oxisol) under intensive rubber (*Hevea brasiliensis*) farming in tropical China by Zhang *et al* (2007) the experiment was conducted with 3 kinds of soil: soil was taken from fields of grass (before rubber plantation), immature rubber (before tapping) and mature rubber (after tapping). The results showed that rubber cultivation in significant decline of soil organic C and microbial biomass C. Available P was extremely low for all kinds of soil, resulting from the naturally low P content and the high sorption capacity of highly weathered Ferralsol. Furthermore, soil pH decreased by about 0.5 units, accompanied by an increase of exchangeable Al by more than one-fold.

Effect of C/N on composting of swine manure with sawdust by Huang *et al* (2004) the experiment was conducted with two aerobic static piles were prepared consisting of swine manure mixed with sawdust in ratio of 3:2 (w/w, fresh weight) and 4:1(w/w, fresh weight), in order to achieve C/N of 30 (pile A) and 15 (pile B), respectively. The results showed that co-composting of swine manure with sawdust at low initial C/N of 15 could reduce the amount of sawdust used, but it would require a composting period of more than 63 days. In addition, the high EC value of the resulted compost had to be reduced to levels that would not exert an inhibition on plant growth.

Effect of natural rubber processing sludge on the degradation of crude oil hydrocarbons in soil by Okieimen *et al* (2002) this research conducted four of the flasks: flask 1, contained oil-contaminated soil without the sludge; flask 2, 3 and 4 contained oil-contaminated soil with 100, 500 and 1,000 mg sludge, respectively. The results showed that natural rubber processing sludge was potential source of nutrient supplement in agriculture.

CHAPTER III

RESEARCH METHODOLOGY

The research regarding utilization of blended fertilizer between centrifuged residue from Para rubber latex and swine manure as growth enhancement for Para rubber seedling composed of 5 key procedures of research methodology as following.

- 3.1 Experimental Location and Laboratory
- 3.2 Material, Laboratory Tools and Equipment
- 3.3 Research Implementation Design
- 3.4 Experiment Planning
- 3.5 Statistical Data Analysis

3.1 Experimental Location and Laboratory

3.1.1. Study site for Para rubber seedling growth experiment

The study was conducted at the deck of Building 1, Faculty of Environment and Resource Studies, Mahidol University, Salaya Campus, Nakhorn Pathom Province.

3.1.2. Chemical Analysis of Soil, Centrifuged Residue, Swine Manure and Water

The chemical analysis of soil, centrifuged residue, swine manure and water was performed at the chemical lab, Phatthanadol Building 1, Faculty of Environment and Resource Studies, Mahidol University, Salaya Campus, Nakhorn Pathom Province and the central lab, Faculty of Science, Mahidol University, Phayathai Campus, Bangkok.

3.2 Material, Laboratory Tools and Equipment

1. Centrifuged residue from Para rubber latex.
2. Swine manure.
3. Uria fertilizer (46-0-0), Diammonium Phosphate fertilizer (18-46-0) and Potassium Chloride fertilizer (0-0-60)
4. RRIM 600 Para rubber seedling variety in polyester bags age 2 months.
5. Experimented soil was Krabi Series (Kbi) (////, 2008)
6. Nursery bags (polyester bag) for seedlings, size 9x16 cm.
7. Experiment tools for fertilizer blending, and for growth of Para rubber seedlings measurement.
8. Laboratory tools and equipment to analyze soil, centrifuged residue from Para rubber latex and swine manure.
9. Chemical substances for properties analysis of soil, centrifuged residue from Para rubber latex and swine manure.
10. Equipment for measurement of young Para rubber seedling growth.

3.3 Research Implementation Design

Research implementation design was divided into 3 parts.

Part 1 Before Experiment

Soil, Centrifuged residue and Swine manure

- pH
- Organic matter
- Total nitrogen
- Available phosphorus
- Available potassium
- Electrical conductivity
- Cation exchange capacity
- %B.S

Part 2 During Experiment

Analysis and measurement of young Para rubber growth for every 15 days until 90 days

- Analysis of leached water during the experiment.
- pH
 - Electrical conductivity
 - TKN
 - Phosphate

- Measurement of young Para rubber seedling growth.
- Number of leaves
 - trunk diameter
 - height of Para rubber seedling

Part 3 After Experiment

Soil analysis after the experiment.

Figure 3-1 Research implementation design

Part 1 Before Experiment data collection and materials analysis were prepared as listed below:

3.3.1 Centrifuged residue from Para rubber latex

Centrifuged residue was collected from Sri Trang Agro-Industry (Plc.), Suratthani Branch) for chemical properties analysis with related parameters as following:

Table 3-1 Parameters and Chemical Properties Analysis for Centrifuged residue

Parameters	Analysis Method
1. pH	pH meter, Land Development Department(LDD), 2001
2. Quantity of organic materials	Walkley and Black, (LDD, 2001)
3. Total Nitrogen	Kjeldahl system. (LDD, 2001)
4. Available Phosphorus	Bray-II, (LDD, 2001)
5. Available Potassium	Flame photometer, (LDD, 2001)
6. Electrical conductivity	Conductivity meter, (LDD, 2001)
7. Cation exchange capacity	Ammonium acetate, (LDD, 2001)
8. %B.S	$\sum(\text{Exch.cation} / \text{CEC}) \times 100$, (LDD, 2001)

3.3.2 Swine Manure

Collection of swine manure from farms without Sodium Hydroxide application for odor eradication and insect repelling was performed for chemical properties analysis. The parameters done were the same as centrifuged residue as shown in **Table 3-1**.

3.3.3 Soil

Soil sampling collection was prepared as representatives of all soil for the experiment in conformity with Land Development Department (26). The purposive sampling was applied to select the soil sample according to the criteria of Land Development Department (26). The soil samplings were collected from Wiang Sa district, Suratthani province as presented in **Figure 3-2**.

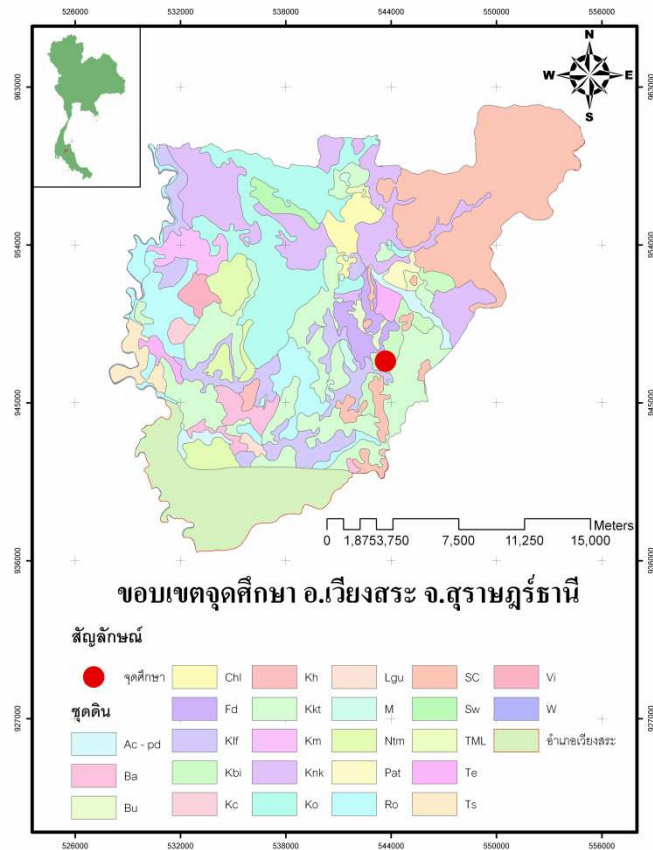


Figure 3-2 Soil Sampling Collection Point

After that soil samples were analyzed for chemical properties according to parameters and analysis methods as same as centrifuged residue mentioned in Table 3-1. The procedure was included bulk density with undisturbed soil sampling by core method at 0-30 cm and 30-50 cm. depth for 3 samples each. Bulk density referred to the proportion of dry soil mass (m_s) and total volume (v_b) (Keawruenrom, 2004). The equation was as follows:

$$P_b = \frac{m_s}{V_b}$$

Then soil was picked up at 0-30 cm. depth and all kept in nursery bags with approximately 9 kg./ bag.

3.3.4 Para rubber seedling

Purposive young Para rubber variety chosen by the researcher was RRIM 600 with age 2 months and was planted in nursery bag size 9 x16 cm.

3.3.5 The experiment consisted of 4 treatments as following

Treatments	Nutrients formula	Conditions
1	Chemical fertilizer formula 20-8-20	Quantity: 5 g/ bag
2	Centrifuged residue and swine manure at proportion of 1:1 by weight	Adjusting by N-P-K elements with chemical substance equivalent to Treatment 1, 5 g/1 bag
3	Centrifuged residue and swine manure in proportion of 1:1	Mixing between centrifuged residue and swine manure, 5g/ bag
4	Without nutrients added (control treatment)	-

***Remark:** soil and nutrients for all 4 treatments were weighted as 9 kg/bag.

Part 2 During Experiment

Chemical properties of water were analyzed for every 15 days to explore loosing of nutrients in watering. The measurement of Para rubber seedling growth was done every 15 days considering from number of leaves. The trunk diameter by using Vernier Caliper and height measuring by tape were done at height of 3 cm. above bud-grafted mark to compare the Para rubber seedling growth per fertilizer utilization of each treatment throughout 90 days.

Table 3-2 Parameters and Analysis Method for water Chemical Properties.

Parameters	Analysis Method
1. pH	pH meter (Department of Environmental Quality Promotion (DEQP),2006)
2. Electrical conductivity	Conductivity meter (DEQP, 2006)
3. TKN	Nesslerization Method (DEQP, 2006)
4. Phosphate	Ascorbic Acid Method (DEQP, 2006)
5. Potassium	Flame photometer (DEQP, 2006)

Part 3 After Experiment

After 90 days of the experiment, soil and water analysis was done with related to parameters as presented in Table 3-1 and Table 3-2 for post analysis results.

3.4 Experiment Planning

The experiment was planned in completely randomized design (CRD). Main plot of the experiment was RRIM 600 seedling age 2 months with the same size cultivated in nursery bag size 31 x 37 cm. Sub plots were treated without various fertilizer formula for 4 treatments and each treatment was added with designed fertilizer formula as shown in item 3.3.5 for 15 trees with 5g/ seedling/ tree (Rubber Research Institute of Thailand, 2007a). In this connection, the nursery was elevated 30 cm. above ground to place seedling where slant with 50-60 % sunlight protection was put on top and covered with plastic sheets to protect rainfall. The experiment needed watering every 2 days in the morning with 275 mm. each the seedling and water container to get the loosing water from nursery bags was placed under plantation experiment throughout 90 days. Measurement of young Para rubber growth was done for every 15 days by considering from number of leaves, trunk diameter and height according to the different fertilizer formula added in each treatment. The measuring tape and venire were applied to measure at 3 cm. above grafted-bud mark and the

analysis of nutrients was performed to investigate the loosing of nutrients by watering every 15 days and also to calculate the actual nutrients utilized by seedling. After that analysis of chemical properties of soil was done after 90 days of cultivation as parameters shown in **Table 3-1**.

Table 3-3 Flowchart of Experiments

Length 12.5 meters

	R1	R2	R3
T1	36	45	60
T2	7	32	43
T3	58	30	47
T4	39	53	23
T1	22	44	28
T2	26	10	24
T3	31	20	40
T4	16	38	52
T1	21	18	59
T2	33	3	34
T3	25	14	51
T4	41	35	15
T1	8	48	5
T2	4	13	29
T3	11	17	9
T4	50	55	46
T1	6	42	37
T2	27	2	57
T3	19	1	12
T4	56	54	49

* Remark *

T1 = Treatment 1
T2 = Treatment 2
T3 = Treatment 3
T4 = Treatment 4
R1 = Row 1
R2 = Row 2
R3 = Row 3
1-60 = Para rubber trees

Width 2 meters

3.5 Statistical Data Analysis

Statistical data was applied with Analysis of Variance (ANOVA) to analyze statistical difference among the experimental groups under distinct treatments for comparative efficiency of each treatment. In case of difference, the procedure would be applied with Tukey' HSD of such variable.

CHAPTER IV

RESULTS

4.1. Properties of soil, centrifuged residue of Para rubber latex and swine manure before experiment

The following investigations were done prior to experiment: soil properties of Krabi soil series at Wiang Sa district, Suratthani province; centrifuged residue of rubber latex from Sri Trang Agro- Industry Plc. (Suratthani Branch); and swine manure from farms in Suratthani province. The results were tabulated in **Table 4.1** which showed the analysis results of pH, organic matter, total Nitrogen, available Phosphorus, exchangeable Potassium, electrical conductivity, cation exchange capacity and percent age of base saturation (%B.S).

It was found that the maximum average of pH of centrifuged residue of rubber latex was 7.71 followed by swine manure and soil as 7.61 and 4.62 respectively. The electricity conductivity in swine manure showed maximum average as 6,846.00 $\mu\text{s}/\text{cm}$. followed by the maximum averages of centrifuged residue and soil as 1,224.00 $\mu\text{s}/\text{cm}$ and 40.38 $\mu\text{s}/\text{cm}$, respectively. The average of organic matter in swine manure was the highest as 35.32 %, followed the centrifuged residue and soil as 12.56 % and 0.91 % respectively. The maximum average of total Nitrogen in centrifuged residue was at 9.73 %, following was the swine manure and soil as 3.30 % and 0.14 % respectively. The average of available Phosphorus in centrifuged residue was the highest at 36.23×10^3 ppm, followed by swine manure and soil at 23.20×10^3 ppm and 3.10 ppm. The maximum average of exchangeable Potassium in swine manure was equivalent to 15.51×10^3 ppm, followed by in centrifuged residue and soil at 0.21×10^3 ppm and 37.28 ppm respectively. For cation exchange capacity and %B.S in swine manure, they had the highest at 27.40 cmol/kg and 398.90 %; followed by centrifuged residue at 13.40 cmol/kg and 189.50 %. The lowest average was found in soil at 4.70 cmol/kg and 34.40 %, respectively.

Table 4-1 Chemical properties of Centrifuged Residue of Rubber Latex, Swine Manure and Soil before and after experiment

Sample	pH	EC($\mu\text{s}/\text{cm}$)	OM(%)	TKN(%)	P(ppm)	K(ppm)	CEC(cmol/kg)	BS (%)
Centrifuged residue	7.71 \pm 0.02	1224.00 \pm 1.58	12.56 \pm 0.27	9.73 \pm 0.05	36.23 x 10 ³	0.21 x 10 ³	13.40	189.50
Swine manure	7.61 \pm 0.06	6846.20 \pm 4.09	35.32 \pm 0.04	3.3 \pm 0.11	23.20 x 10 ³	15.51 x 10 ³	27.40	398.90
Soil before	4.62 \pm 0.01	40.38 \pm 0.38	0.91 \pm 0.05	0.14 \pm 0.01	3.1 \pm 0.10	37.28 \pm 0.34	4.70	34.40
Soil (after)								
Treatment 1	4.76 \pm 0.17a ^{1/}	137.32 \pm 21.09a ^{1/}	0.82 \pm 0.09a ^{1/}	0.12 \pm 0.02a ^{1/}	37.95 \pm 5.31c ^{1/}	35.13 \pm 4.56c	5.33 \pm 0.13b ^{1/}	1,719.28 \pm 84.43b ^{1/}
Treatment 2	5.01 \pm 0.12b	128.85 \pm 11.38a	0.92 \pm 0.07b	0.13 \pm 0.02a	5.19 \pm 0.40b	24.83 \pm 2.65b	5.45 \pm 0.21b	1,740 \pm 121.52b
Treatment 3	4.99 \pm 0.13b	125.79 \pm 16.78a	0.92 \pm 0.07b	0.13 \pm 0.01a	3.51 \pm 0.23b	14.87 \pm 1.26a	5.43 \pm 0.22b	1,503.59 \pm 126.93a
Control	5.04 \pm 0.14b	94.12 \pm 5.19b	0.81 \pm 0.08a	0.13 \pm 0.01a	0	14.99 \pm 1.55a	5.02 \pm 0.07a	1,514.75 \pm 56.51a

Mean \pm SD (n = 15), 1/ = similar English alphabets at the vertical axis showed indifferent value of statistically significant level at 0.05 by Tukey's HSD method. However, different English alphabets in vertical axis showed the difference of statistically significant level at 0.05 by Tukey's HSD method. If there is more than one alphabet in the vertical axis, for example ab, it meant that there was no difference of statistically significant level at 0.05 from a and b by Tukey's HSD method. Treatment 1 was the chemical fertilizer at the concentration of 20-8-20. Treatment 2 was the mixture of centrifuged residue and swine manure with adjustment of N-P-K value by chemical fertilizer at the concentration of 20-8-20. Treatment 3 was the mixture of the centrifuged residue and swine manure in the proportion of 1:1. And Treatment 4 was the control.

4.2 Soil properties after experiment

After 90 days of experiment, soil sample analysis was conducted for chemical properties with the following parameters: pH, organic matter, total Nitrogen, available phosphorus, exchangeable Potassium, electrical conductivity, cation exchange capacity and %B.S. The experiment composed of 4 Treatments: Treatment 1 was the chemical fertilizer with 20-8-20; Treatment 2 was the mixture of centrifuged residue and swine manure in proportion of 1:1 adjusted by N-P-K elements with chemical substance for the concentration of 20-8-20; Treatment 3 was the mixture of centrifuged residue and swine manure any in the proportion of 1:1; Treatment 4 was the control set (original soil without elements added) as presented in **Table 4.1**.

4.2.1 pH Value

The utilization of soil nutrients radically depend on pH value. Para rubber capability to utilize soil nature usually grows high or moderate. It is capable of adjusting in soil condition with low or rather low fertility, with pH ranges 4.5-5.5 (15). From analyzed result of pH value prior to experiment, the pH value was about 4.62 while the analysis after experiment was found that the highest average of soil in the control set at 5.04; followed by Treatment 2 which was the centrifuged residue and swine manure in proportion of 1:1 adjusted by N-P-K elements with chemical substance for the concentration of 20-8-20 with 5.01; and in Treatment 3 which was the mixture of centrifuged residue and swine manure in the proportion of 1:1 as 4.99. Treatment 1 which was the chemical fertilizer formula 20-8-20 showed the lowest pH value as 4.76, respectively.

Regarding the statistical test results, the pH value in each Treatment showed none of significantly statistical difference with the control set at significance level of 0.05. But for Treatment 2, Treatment 3 and control set had more pH value than Treatment 1 at significantly statistical difference of 0.05 as detail shown in **Table 4.1** and **Figure 4-1**.

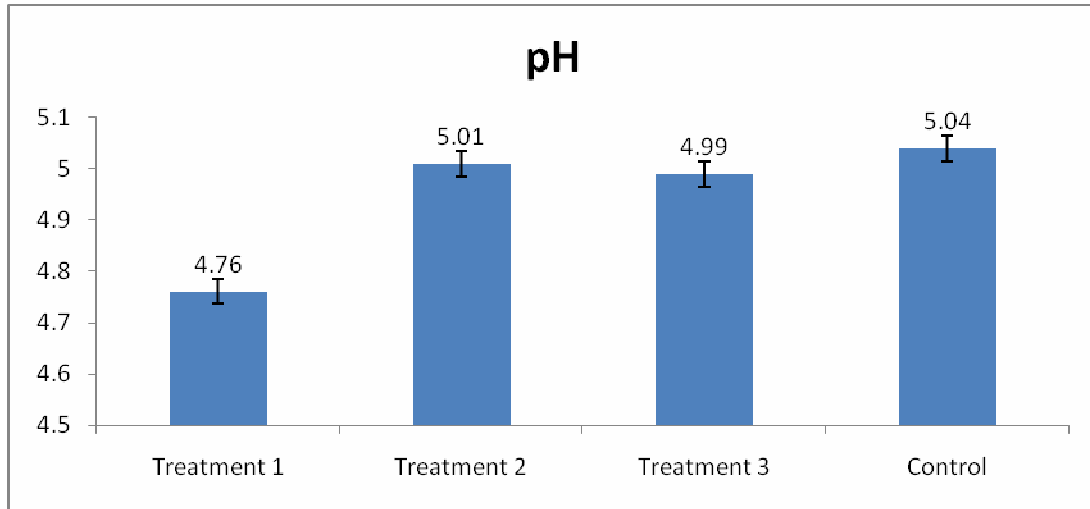


Figure 4-1 the values of pH (Treatment 1 was the chemical fertilizer at the concentration of 20-8-20. Treatment 2 was the mixture of centrifuged residue and swine manure with adjustment of N-P-K value by chemical fertilizer at the concentration of 20-8-20. Treatment 3 was the mixture of the centrifuged residue and swine manure in the proportion of 1:1. And Treatment 4 was the control set.)

4.2.2 Electrical conductivity

From the analysis of electrical conductivity, the result was found that Treatment 1, the chemical fertilizer formula 20-8-20, had the highest average of electrical conductivity at 137.32 $\mu\text{s}/\text{cm}$. followed by Treatment 2, the mixture of centrifuged residue and swine manure in proportion of 1:1 adjusted by N-P-K elements with chemical substance for the concentration of 20-8-20 and Treatment 3, the mixture of centrifuged residue and swine manure in the proportion of 1:1 and the control experiment were 128.85 $\mu\text{s}/\text{cm}$, 125.79 $\mu\text{s}/\text{cm}$. and 94.12 $\mu\text{s}/\text{cm}$, respectively.

The statistical test found that each Treatment was different to the control set with statistical difference at 0.05. Specifically, the highest electrical conductivity in Treatment 1 was more than the control set followed by Treatment 2 and Treatment 3, respectively as presented in **Table 4.1** and **Figure 4-2**.

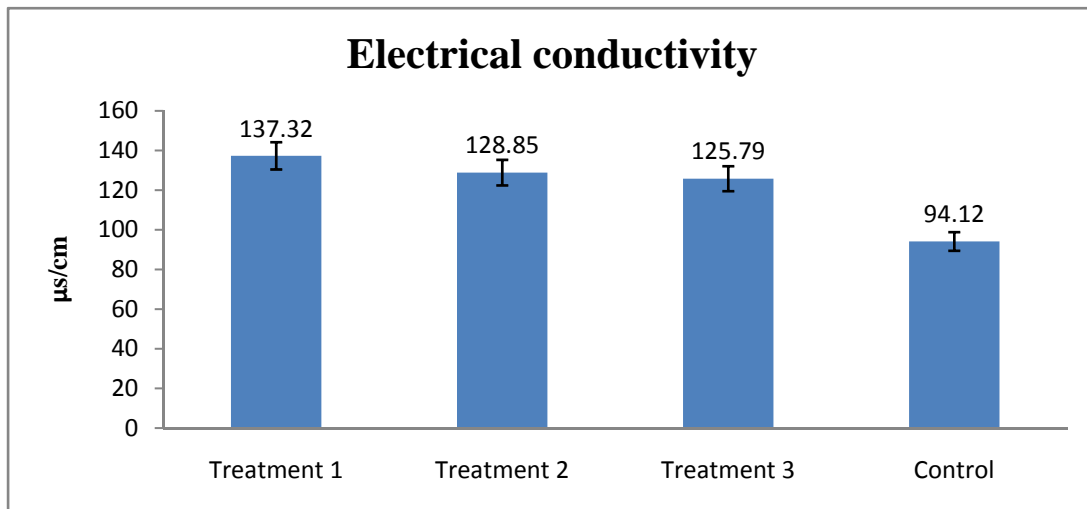


Figure 4-2 The values of EC (Treatment 1 was the chemical fertilizer at the concentration of 20-8-20. Treatment 2 was the mixture of centrifuged residue and swine manure with adjustment of N-P-K value by chemical fertilizer at the concentration of 20-8-20. Treatment 3 was the mixture of the centrifuged residue and swine manure in the proportion of 1:1. And Treatment 4 was the control set.)

4.2.3 Organic Matter

According to organic matter analysis after experiment, the findings indicated that Treatment 2, the mixture centrifuged residue and swine manure in proportion of 1:1 adjusted N-P-K elements with chemical substance for the concentration of 20-8-20, and Treatment 3, the mixture of centrifuged residue and swine manure in the proportion of 1:1 showed the maximum average of organic matter at 0.92%; followed by Treatment 1, the chemical fertilizer formula 20-8-20, and the control set, without any material added with the average value as 0.82% and 0.81%, respectively.

Regarding the statistic test results, Treatment 2 and Treatment 3 contained more organic matter than control set with statistical difference at 0.05. Treatment 1 found less organic matter than Treatment 2 and Treatment 3 but none of difference with the control set with significantly statistical difference at 0.05 as shown in **Table 4.1** and **Figure 4-3**.

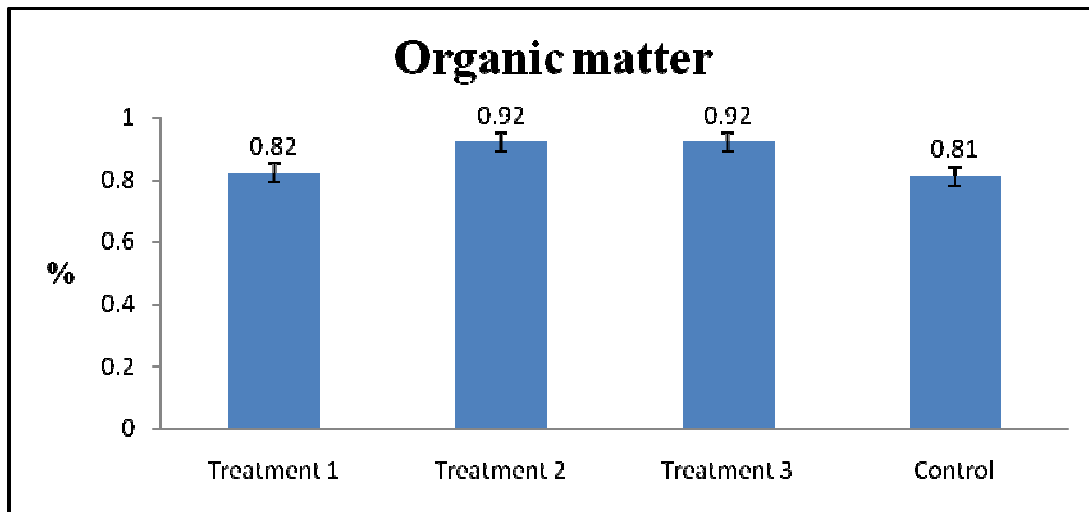


Figure 4-3 The value of Organic Matter (Treatment 1 was the chemical fertilizer at the concentration of 20-8-20. Treatment 2 was the mixture of centrifuged residue and swine manure with adjustment of N-P-K value by chemical fertilizer at the concentration of 20-8-20. Treatment 3 was the mixture of the centrifuged residue and swine manure in the proportion of 1:1. And Treatment 4 was the control set.)

4.2.4 Total Nitrogen

The analysis results of total Nitrogen in soil, it was found that each Treatment contained similarly average total Nitrogen. Considering in details among treatments, Treatment 2 which was the mixture of centrifuged residue and swine manure in proportion of 1:1 adjusted N-P-K elements with chemical substance for the concentration of 20-8-20, Treatment 3 which composed of the mixture of centrifuged residue and swine manure in the proportion of 1:1 and the control set, had the total Nitrogen equivalent to 0.13%, while Treatment 1, which was the chemical fertilizer formula 20-8-20, had the average total Nitrogen at 0.12%.

With regard to statistical test result, each Treatment had no significantly statistical difference at 0.05 as shown in **Table 4.1** and **Figure 4-4**.

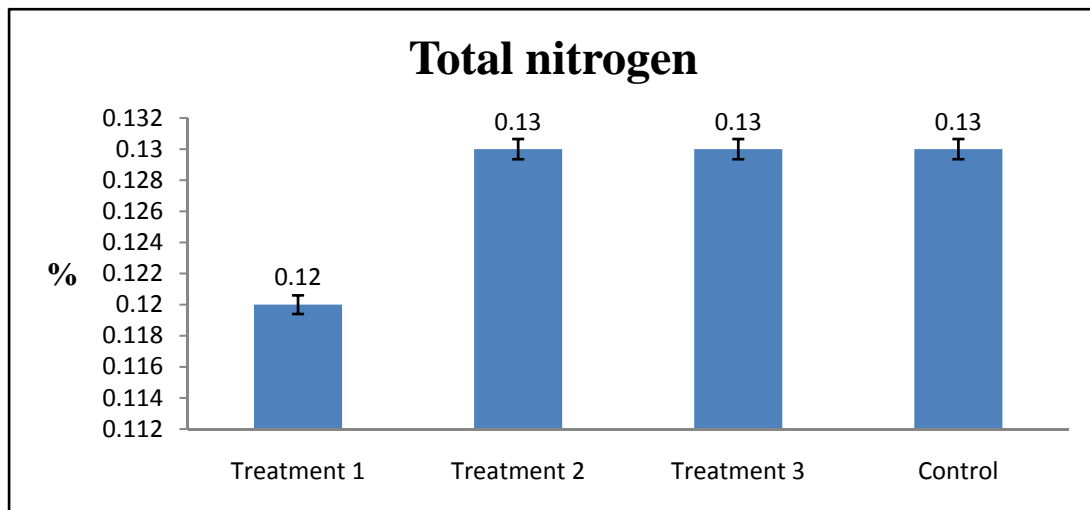


Figure 4-4 The values of Total nitrogen (Treatment 1 was the chemical fertilizer at the concentration of 20-8-20. Treatment 2 was the mixture of centrifuged residue and swine manure with adjustment of N-P-K value by chemical fertilizer at the concentration of 20-8-20. Treatment 3 was the mixture of the centrifuged residue and swine manure in the proportion of 1:1. And Treatment 4 was the control set.)

4.2.5 Available Phosphorus

The analysis results of available Phosphorus in soil, Treatment 1, the chemical fertilizer formula 20-8-20, had the available phosphorus at the highest amount of 37.95 ppm; followed by Treatment 2, the mixture of centrifuged residue and swine manure in proportion of 1:1 adjusted N-P-K elements with chemical substance for the concentration of 20-8-20, and Treatment 3 which composed of the mixture of centrifuged residue and swine manure in the proportion of 1:1, had the average available Phosphorus as 5.19 ppm and 3.51 ppm, respectively. For the lowest quantity, the available Phosphorus was rarely detected in control set.

For the statistical test result, the available Phosphorus of all Treatments were found higher than the control set with significantly statistical difference at 0.05. The most significant difference was showed in Treatment 1 followed by Treatment 2 and Treatment 3, respectively with the significantly statistical difference at 0.05. The most was found in Treatment 1 more than in Treatment 3 while Treatment 1 was higher than Treatment 2, respectively. But between Treatment 2 and Treatment 3,

none of statistical difference was found in significant level at 0.05 as tabulated in **Table 4.1** and **Figure 4-5**.

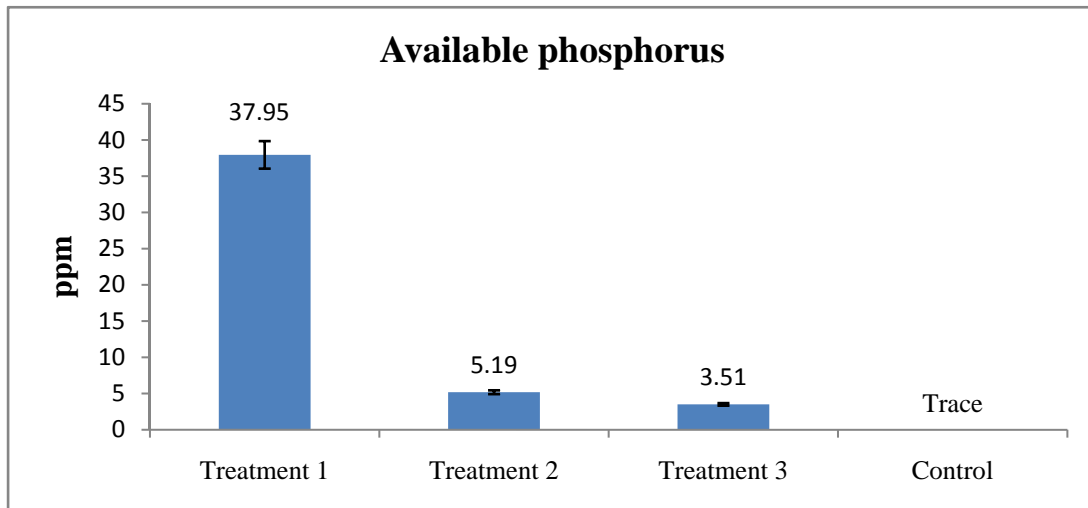


Figure 4-5 The values of available phosphorus (Treatment 1 was the chemical fertilizer at the concentration of 20-8-20. Treatment 2 was the mixture of centrifuged residue and swine manure with adjustment of N-P-K value by chemical fertilizer at the concentration of 20-8-20. Treatment 3 was the mixture of the centrifuged residue and swine manure in the proportion of 1:1. And Treatment 4 was the control set.)

4.2.6 Exchangeable Potassium

From the analyzed result, the analysis of exchangeable Potassium in soil after experiment for Treatment 1, the chemical fertilizer formula 20-8-20, the exchangeable Phosphorus, was found with the highest amount of 35.13 ppm.; followed by Treatment 2, the mixture of centrifuged residue and swine manure in proportion of 1:1 adjusted by N-P-K elements with chemical substance for the concentration of 20-8-20, and the control set, the exchangeable Phosphorus were equivalent to 24.83 ppm. and 14.99 ppm., respectively. The lowest average was found in Treatment 3, the mixture of centrifuged residue and swine manure in the proportion of 1: 1, at 14.87 ppm.

Regarding the statistical test result, the exchangeable Phosphorus in Treatment 1 and Treatment 2 were found higher than in the control set with significantly statistical difference at 0.05. Among Treatments 1, 2 and 3, the significant difference was found with significantly statistical level at 0.05 as well. Specifically, the most quantity was found in Treatment 1 followed by Treatment 2 and Treatment 3, respectively as detail shown in **Table 4.1** and **Figure 4-6**.

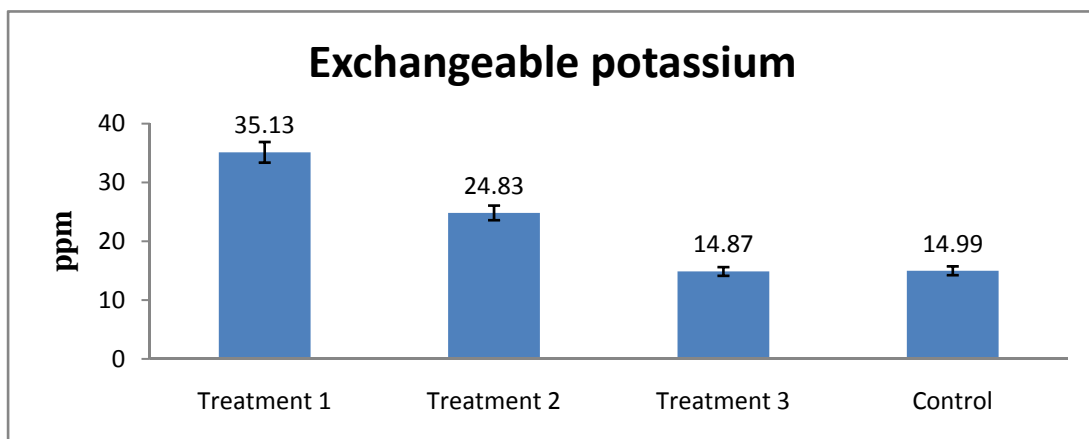


Figure 4-6 The values of exchangeable potassium (Treatment 1 was the chemical fertilizer at the concentration of 20-8-20. Treatment 2 was the mixture of centrifuged residue and swine manure with adjustment of N-P-K value by chemical fertilizer at the concentration of 20-8-20. Treatment 3 was the mixture of the centrifuged residue and swine manure in the proportion of 1:1. And Treatment 4 was the control set.)

4.2.7 Cation exchange capacity (CEC)

The analyzed results of cation exchange capacity (CEC) were found that Treatment 2, the mixture of centrifuged residue and swine manure in proportion of 1:1 adjusted N-P-K chemical fertilizer for the concentration of 20-8-20, the cation exchange capacity (CEC) was the highest amount of 5.45 cmol/kg.; Treatment 3 which was the mixture only the centrifuged residue and swine manure in the proportion of 1:1, and Treatment 1 which was used only chemical fertilizer formula 20-8-20 and control set, the average values were equivalent to 5.43 cmol/kg. 5.33 mol/kg. and 5.02 cmol/kg., respectively.

The result of statistical test was found that each Treatment was significantly different to the control set at statistically significant difference at 0.05. Treatment 2 was found the highest CEC, greater than the control set; followed by Treatment 3 and Treatment 1 which had more CEC than the control set, respectively as shown in **Table 4.1** and **Figure 4-7**.

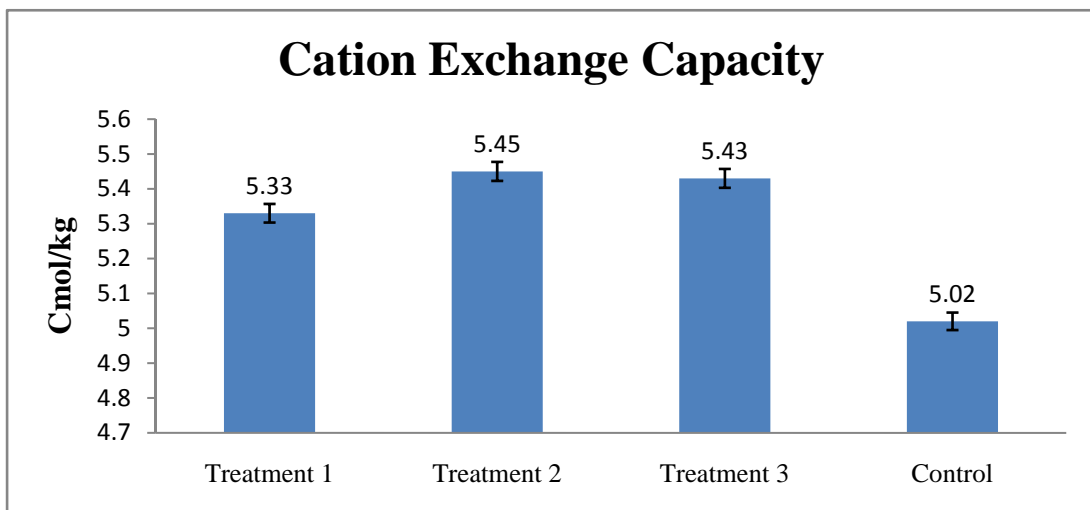


Figure 4-7 The values of CEC (Treatment 1 was the chemical fertilizer at the concentration of 20-8-20. Treatment 2 was the mixture of centrifuged residue and swine manure with adjustment of N-P-K value by chemical fertilizer at the concentration of 20-8-20. Treatment 3 was the mixture of the centrifuged residue and swine manure in the proportion of 1:1. And Treatment 4 was the control set.)

4.2.8 Percentage of base saturation (% B.S)

For the analyzed results of %BS, the highest amount was 1,740.27 % and found in Treatment 2, the mixture of centrifuged residue and swine manure in proportion of 1:1 adjusted by N-P-K chemical fertilizer for the concentration of 20-8-20. The average results were followed by Treatment 1 with the chemical fertilizer formula 20-8-20, the control set and Treatment 3, the mixture only the centrifuged residue and swine manure in the proportion of 1:1, as 1,719.28 %, 1,514.75 % and 1,503.59 %, respectively.

Based on statistical test result, %BS in Treatment 1 and Treatment 2 was found greater than in the control set with significantly statistical difference at 0.05. The highest amount of %BS was found in Treatment 2, greater than in the control set respectively. Among Treatment 1, 2 and 3, the significant difference was found with significantly statistical level at 0.05 as well. The most %BS was in Treatment 2 and greater than in Treatment 3; followed by Treatment 1 that greater than in Treatment 3 respectively; while none of %BS difference was found in Treatment 1 and Treatment 2 as shown in **Table 4.1** and **Figure 4-8**.

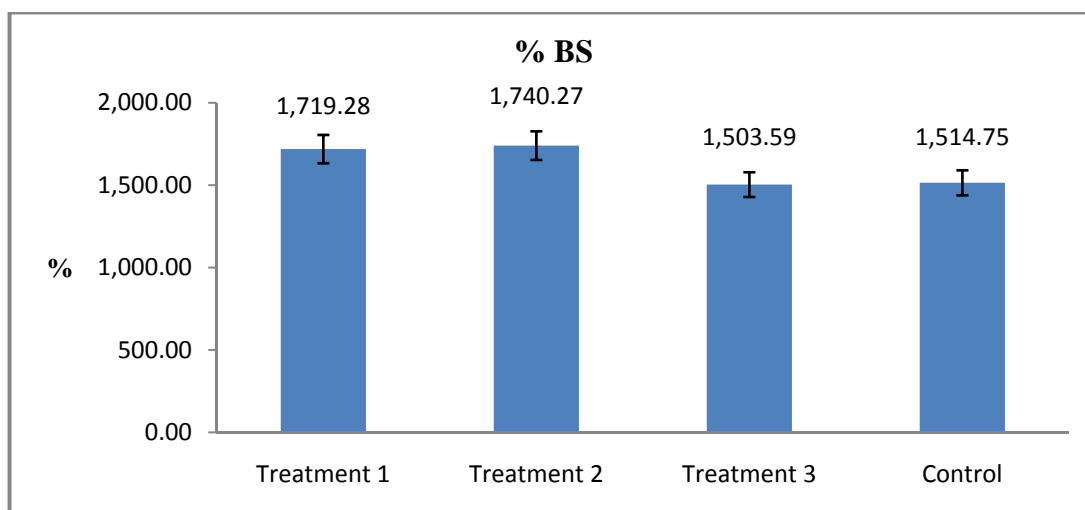


Figure 4-8 The value of %BS (Treatment 1 was the chemical fertilizer at the concentration of 20-8-20. Treatment 2 was the mixture of centrifuged residue and swine manure with adjustment of N-P-K value by chemical fertilizer at the concentration of 20-8-20. Treatment 3 was the mixture of the centrifuged residue and swine manure in the proportion of 1:1. And Treatment 4 was the control set.)

4.3 Nutrient leachate

During experiment, water flowing from watering Para rubber seedling was typically stored every 15 days for lost nutrient analysis. The investigated parameters were in terms of:

- pH
- Electrical conductivity
- Total Nitrogen
- Available Phosphorus
- Available Potassium

4.3.1 pH

Table 4-2 The Values of pH (Mean \pm SD, n = 15)

Day	Treatment1	Treatment2	Treatment3	Control
0	6.50 \pm 0.01a ^{1/}	6.52 \pm 0.01b	6.69 \pm 0.01d	6.62 \pm 0.02c
15	6.45 \pm 0.01a ^{1/}	6.44 \pm 0.01b	6.68 \pm 0.01d	6.62 \pm 0.02c
30	6.39 \pm 0.01a ^{1/}	6.40 \pm 0.01b	6.65 \pm 0.01d	6.62 \pm 0.01c
45	6.36 \pm 0.01a ^{1/}	6.36 \pm 0.01a	6.64 \pm 0.01c	6.62 \pm 0.01b
60	6.34 \pm 0.01a ^{1/}	6.35 \pm 0.01a	6.63 \pm 0.01c	6.61 \pm 0.01b
75	6.22 \pm 0.01b ^{1/}	6.20 \pm 0.01a	6.60 \pm 0.03c	6.61 \pm 0.01c
90	6.02 \pm 0.03a ^{1/}	6.00 \pm 0.01a	6.60 \pm 0.01b	6.60 \pm 0.02b

1/ = similar English alphabet at the vertical axis showed indifferent value of statistically significant at 0.05 levels by Tukey's HSD method. However, different English alphabets in vertical axis showed the difference of statistically significant at 0.05 levels by Tukey's HSD method. If there was more than one alphabet in the vertical axis, for example ab, it means that there was no difference of statistically significant at 0.05 levels from a and b by Tukey's HSD method. Treatment 1 was the chemical fertilizer at the concentration of 20-8-20. Treatment 2 was the mixture of centrifuged residue and swine manure with adjustment of N-P-K value by chemical fertilizer at the concentration of 20-8-20. Treatment 3 was the mixture of the centrifuged residue and swine manure in the proportion of 1:1. And Treatment 4 was the control set.

To consider the pH variance following the time frame, pH in each Treatment gradually descended in value. For Treatment 1 adding the chemical fertilizer with 20-8-20 in days 0, 15, 30, 45, 60, 75 and 90, the average pH values were equivalent to 6.50, 6.45, 6.39, 6.36, 6.34, 6.22 and 6.02, respectively.

For Treatment 2 which was the mixture of centrifuged residue and swine manure in proportion of 1:1 adjusted N-P-K value with chemical fertilizer for the concentration of 20-8-20 in days 0, 15, 30, 45, 60, 75 and 90, the average pH values were equivalent to 6.52, 6.44, 6.40, 6.36, 6.35, 6.20 and 6.00, respectively.

For Treatment 3 which contained with mixture of the centrifuged residue and swine manure in the proportion of 1: 1 in days 0, 15, 30, 45, 60, 75 and 90, the average pH values were equivalent to 6.69, 6.68, 6.65, 6.64, 6.63, 6.60 and 6.60, respectively.

Furthermore, in the control set, which none of elements of an experiment were added in days 0, 15, 30, 45, 60, 75 and 90, the average pH values were slightly changed, equivalent to 6.62, 6.62, 6.62, 6.62, 6.61, 6.61 and 6.60, respectively.

To consider the statistical test result, each Treatment was different to the control set with significantly statistical difference at 0.05.

4.3.2 Electrical Conductivity

Table 4-3 The values of EC ($\mu\text{s}/\text{cm}$) (Mean \pm SD, n = 15)

Day	Treatment1	Treatment2	Treatment3	Control
0	1462.67 \pm 0.90d ^{1/}	1444.20 \pm 2.43c	1406.33 \pm 2.87b	559.60 \pm 2.13a
15	1447.47 \pm 0.90d ^{1/}	767.07 \pm 1.67c	655.67 \pm 2.16b	552.60 \pm 2.87a
30	1281.40 \pm 0.90d ^{1/}	746.20 \pm 2.70c	645.00 \pm 1.56b	537.13 \pm 2.75a
45	1200.80 \pm 0.90d ^{1/}	705.13 \pm 2.61c	603.67 \pm 2.26b	525.47 \pm 2.85a
60	1143.20 \pm 1.20d ^{1/}	665.07 \pm 2.19c	555.67 \pm 1.80b	506.93 \pm 2.02a
75	1029.00 \pm 0.80d ^{1/}	614.67 \pm 2.50c	525.20 \pm 2.18b	495.00 \pm 3.21a
90	971.00 \pm 1.60d ^{1/}	572.47 \pm 2.75c	503.67 \pm 2.16b	487.87 \pm 2.17a

1/ = similar English alphabet at the vertical axis showed indifferent value of statistically significant at 0.05 levels by Tukey's HSD method. However, different English alphabets in vertical axis showed the difference of statistically significant at 0.05 levels by Tukey's HSD method. If there was more than one alphabet in the vertical axis, for example ab, it means that there was no difference of statistically significant at 0.05 levels from a and b by Tukey's HSD method. Treatment 1 was the chemical fertilizer at the concentration of 20-8-20. Treatment 2 was the mixture of centrifuged residue and swine manure with adjustment of N-P-K value by chemical fertilizer at the concentration of 20-8-20. Treatment 3 was the mixture of the centrifuged residue and swine manure in the proportion of 1:1. And Treatment 4 was the control set.

Consideration of EC by time frame, each Treatment gradually descended in values. For Treatment 1 adding the chemical fertilizer formula 20-8-20 in days 0, 15, 30, 45, 60, 75 and 90, the average electrical conductivity values were equivalent to 1462.67 $\mu\text{s}/\text{cm}$, 1447.47 $\mu\text{s}/\text{cm}$, 1281.40 $\mu\text{s}/\text{cm}$, 1200.80 $\mu\text{s}/\text{cm}$, 1143.20 $\mu\text{s}/\text{cm}$, 1029.00 $\mu\text{s}/\text{cm}$ and 971.00 $\mu\text{s}/\text{cm}$, respectively.

For Treatment 2 which was the mixture of centrifuged residue and swine manure in proportion of 1:1 adjusted N-P-K value with chemical fertilizer for the concentration of 20-8-20 in days 0, 15, 30, 45, 60, 75 and 90, the average electrical conductivity values were equivalent to 1444.20 $\mu\text{s}/\text{cm}$, 767.07 $\mu\text{s}/\text{cm}$, 746.20 $\mu\text{s}/\text{cm}$, 705.13 $\mu\text{s}/\text{cm}$, 665.07 $\mu\text{s}/\text{cm}$, 614.67 $\mu\text{s}/\text{cm}$ and 572.47 $\mu\text{s}/\text{cm}$, respectively.

In Treatment 3 which contained the mixture of centrifuged residue and swine manure in the proportion of 1: 1 in days 0, 15, 30, 45, 60, 75 and 90, the average electrical conductivity values were equivalent to 1406.33 $\mu\text{s}/\text{cm}$, 655.67 $\mu\text{s}/\text{cm}$, 645.00 $\mu\text{s}/\text{cm}$, 603.67 $\mu\text{s}/\text{cm}$, 555.67 $\mu\text{s}/\text{cm}$, 525.20 $\mu\text{s}/\text{cm}$ and 503.67 $\mu\text{s}/\text{cm}$, respectively.

Furthermore, for the control set, which none of elements of an experiment were added in days 0, 15, 30, 45, 60, 75 and 90, the average electrical conductivity values were equivalent to 559.60 $\mu\text{s}/\text{cm}$, 552.60 $\mu\text{s}/\text{cm}$, 537.13 $\mu\text{s}/\text{cm}$, 525.47 $\mu\text{s}/\text{cm}$, 506.93 $\mu\text{s}/\text{cm}$, 495.00 $\mu\text{s}/\text{cm}$ and 487.87 $\mu\text{s}/\text{cm}$, respectively.

To consider the statistical test, each Treatment differed from the control set with significantly statistical level at 0.05.

4.3.3 Total Nitrogen

Table 4-4 The values of Total Nitrogen (%) (Mean \pm SD, n = 15)

Day	Treatment1	Treatment2	Treatment3	Control
0	3.62 \pm 0.27c ^{1/}	1.57 \pm 0.32b	0.37 \pm 0.14a	nil
15	2.73 \pm 0.44c ^{1/}	0.49 \pm 0.20b	0.07 \pm 0.13a	nil
30	1.58 \pm 0.28b ^{1/}	0.06 \pm 0.12a	nil	nil
45	0.39 \pm 0.14b ^{1/}	nil	nil	nil
60	nil	nil	nil	nil
75	nil	nil	nil	nil
90	nil	nil	nil	nil

1/ = similar English alphabet at the vertical axis showed indifferent value of statistically significant at 0.05 levels by Tukey's HSD method. However, different English alphabets in vertical axis showed the difference of statistically significant at 0.05 levels by Tukey's HSD method. If there was more than one alphabet in the vertical axis, for example ab, it meant that there was no difference of statistically significant at 0.05 levels from a and b by Tukey's HSD method. Treatment 1 was the chemical fertilizer at the concentration of 20-8-20. Treatment 2 was the mixture of centrifuged residue and swine manure with adjustment of N-P-K value by chemical fertilizer at the concentration of 20-8-20. Treatment 3 was the mixture of the centrifuged residue and swine manure in the proportion of 1:1. And Treatment 4 was the control set.

To consider the total Nitrogen by time frame, the findings was that none of total Nitrogen was found in the control set. But in Treatment 1 adding the chemical fertilizer formula 20-8-20, Treatment 2 with the mixture of centrifuged residue and swine manure in proportion of 1:1 adjusted N-P-K elements with chemical fertilizer for the concentration of 20-8-20 and Treatment 3 containing only the mixture of centrifuged residue and swine manure in the proportion of 1: 1, the total Nitrogen gradually descend in value to nil. Specifically for Treatment 1, the average total

Nitrogen was found the average values of days 0, 15, 30 and 45 at 3.62%, 2.73%, 1.58%, 2.73%, 1.58% and 0.39%. While Treatment 2, the average total Nitrogen was found only in days 0, 15 and 30 at the average values of 1.57%, 0.49% and 0.06 %. For Treatment 3, the total Nitrogen in day 0 was averagely equivalent to 0.37% and day 15 at 0.07%.

To consider the statistical test result, each Treatment during day 0 to day 45 was different to the dominance set with significantly statistical difference at 0.05 levels.

4.3.4 Available Phosphorus

Table 4-5 The values of available phosphorus (ppm) (Mean \pm SD, n = 15)

Day	Treatment1	Treatment2	Treatment3	Control
0	0.18 \pm 0.10b ^{1/}	0.02 \pm 0.02a	0.02 \pm 0.01a	nil
15	nil	nil	nil	nil
30	nil	nil	nil	nil
45	nil	nil	nil	nil
60	nil	nil	nil	nil
75	nil	nil	nil	nil
90	nil	nil	nil	nil

1/ = similar English alphabet at the vertical axis showed indifferent value of statistically significant at 0.05 levels by Tukey's HSD method. However, different English alphabets in vertical axis showed the difference of statistically significant at 0.05 levels by Tukey's HSD method. If there was more than one alphabet in the vertical axis, for example ab, it meant that there was no difference of statistically significant at 0.05 levels from a and b by Tukey's HSD method. Treatment 1 was the chemical fertilizer at the concentration of 20-8-20. Treatment 2 was the mixture of centrifuged residue and swine manure with adjustment of N-P-K value by chemical fertilizer at the concentration of 20-8-20. Treatment 3 was the mixture of the centrifuged residue and swine manure in the proportion of 1:1. And Treatment 4 was the control set.

Regarding available phosphorus quantity within the time frame, available phosphorus was not found in the control set. However, in Treatment 1, the chemical fertilizer at the concentration of 20-8-20; Treatment 2, mixture of centrifuged residue and swine manure with adjusted N-P-K value by chemical fertilizer at the

concentration of 20-8-20; and Treatment 3, mixture of centrifuged residue and swine manure in the proportion of 1:1, available phosphorus was only found in Day 0 with the highest quantity of 0.18 ppm in Treatment 1. The following were Treatment 2 and Treatment 3 with an equivalent quantity of 0.02 ppm.

To consider the statistic test results, it was found that each Treatment of Day 0 differed from the control set at the statistically significant level of 0.05.

4.3.5 Exchangeable Potassium

Table 4-6 The values of exchangeable potassium (ppm) (Mean \pm SD, n = 15)

Day	Treatment1	Treatment2	Treatment3	Control
0	7.00 \pm 0.38b ^{1/}	6.83 \pm 0.20b	5.95 \pm 0.93a	nil
15	6.36 \pm 0.59c ^{1/}	5.78 \pm 0.44b	3.45 \pm 0.67a	nil
30	5.68 \pm 0.64c ^{1/}	4.62 \pm 1.01b	1.66 \pm 0.35a	nil
45	4.49 \pm 0.96c ^{1/}	1.79 \pm 0.33b	0.81 \pm 0.11a	nil
60	3.37 \pm 0.85b ^{1/}	0.16 \pm 0.02a	nil	nil
75	1.98 \pm 0.62b ^{1/}	nil	nil	nil
90	0.94 \pm 0.52b ^{1/}	nil	nil	nil

^{1/} = similar English alphabet at the vertical axis showed indifferent value of statistically significant at 0.05 levels by Tukey's HSD method. However, different English alphabets in vertical axis showed the difference of statistically significant at 0.05 levels by Tukey's HSD method. If there was more than one alphabet in the vertical axis, for example ab, it means that there was no difference of statistically significant at 0.05 levels from a and b by Tukey's HSD method. Treatment 1 was the chemical fertilizer at the concentration of 20-8-20. Treatment 2 was the mixture of centrifuged residue and swine manure with adjustment of N-P-K value by chemical fertilizer at the concentration of 20-8-20. Treatment 3 was the mixture of the centrifuged residue and swine manure in the proportion of 1:1. And Treatment 4 was the control set.

Regarding the quantity of exchangeable potassium within the time frame, no exchangeable potassium was found in the control set. However, in Treatment 1, the chemical fertilizer at the concentration of 20-8-20; Treatment 2, the mixture of centrifuged residue blended with swine manure adjusted N-P-K value by chemical fertilizer at the concentration of 20-8-20; and Treatment 3, the mixture of centrifuged residue and swine manure in the proportion of 1:1, gradually descend in value to nil. From Day 0, 15, 30 and 45, it was found that the highest value of the exchangeable

potassium in Treatment 1 were 7.00 ppm, 6.36 ppm, 5.68 ppm and 4.49 ppm, respectively. Following was the Treatment 2 with an average quantity of 6.83 ppm, 5.78 ppm, 4.62 ppm and 1.79 ppm, respectively and Treatment 3 with an average quantity of 5.95 ppm, 3.45 ppm, 1.66 ppm and 0.81 ppm, respectively.

For the statistic test results, it was found that each Treatment differed from the control set at the statistically significant level of 0.05.

After 60 days, the highest average value of exchangeable potassium was in Treatment 1 at 3.37 ppm; the following was the Treatment 2 with average value at 0.16 ppm. However, no exchangeable potassium quantity was found in Treatment 3.

Regarding the statistic test results, it was found that each Treatment differed from the control sets at the statistically significant level of 0.05

During 75 and Day 90, the exchangeable potassium was found only in Treatment 1 at the values of 1.98 ppm and 0.94 ppm, respectively. Regarding the statistic test results, it was found that there was a statistically significant level of 0.05 between the control set and each Treatment.

4.4 Growth Development of Para rubber seedling

From this experiment, the RRIM 600 Para rubber seedling variety age 2 months planted in nursery bags, derived from the cross-hybrid of Tjir variety and PB 86 variety from Malaysia, which is the most popular variety among farmers because it provides more rubber latex than other variety and has good growth rate during rubber latex tapping. The measurement of the Para rubber seedling growth was made at 3 cm. height from the bud-grafted mark for every 15 days throughout the 90 days experiment period considering the height (cm.), trunk diameter (mm.) and numbers of leaves.

4.4.1 Height (cm.)

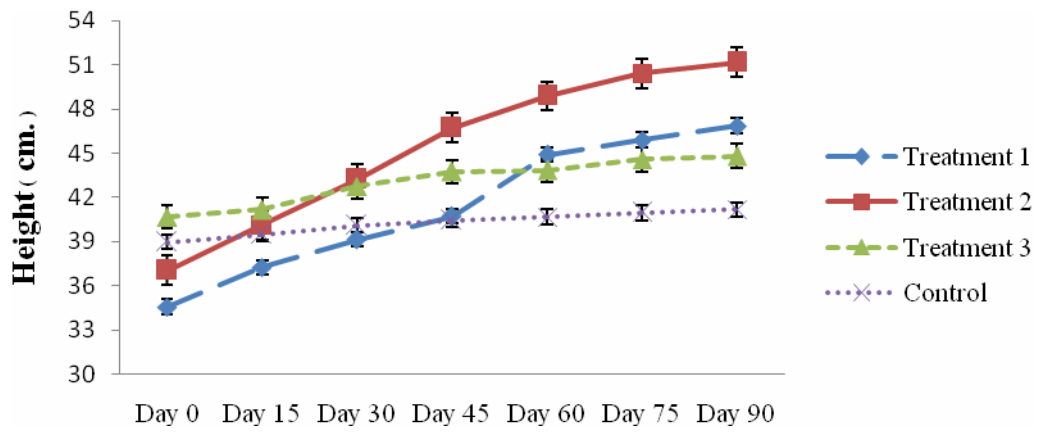


Figure 4-9 Height of Para rubber seedling (cm.)

Table 4-7 Growth of Para rubber seedling (cm.)

Treatment No.	Day 0	Day 15	Day 30	Day 45	Day 60	Day 75	Day 90
1.	34.57±6.15a ^{1/}	37.25±6.56a ^{1/}	39.15±6.40a ^{1/}	40.71±6.67a ^{1/}	44.89±10.31a ^{1/}	45.89±10.46ab ^{1/}	46.86±10.26ab ^{1/}
2.	37.05±4.40a	40.15±5.54a	43.23±4.95a	46.71±6.74a	48.47±8.35a	50.43±10.43b	51.15±10.49b
3.	40.65±6.79a	41.16±6.67a	42.74±6.65a	43.47±6.48a	43.84±6.44a	44.57±5.93ab	44.81±5.88ab
Control	38.97±9.60a	39.49±9.69a	40.10±9.99a	40.44±10.07a	40.67±10.26a	40.94±10.56a	41.17±10.60a

Mean ± SD (n = 15), 1/ = similar English alphabet at the vertical axis showed indifferent value of statistically significant at 0.05 levels by Tukey's HSD method. However, different English alphabets in vertical axis showed the difference of statistically significant at 0.05 levels by Tukey's HSD method. If there was more than one alphabet in 160he vertical axis, for example ab, it meant that there was no difference of statistically significant at 0.05 levels from a and b by Tukey's HSD method. Treatment 1 is the chemical fertilizer at the concentration of 20-8-20. Treatment 2 was the mixture of centrifuged residue and swine manure with adjustment of N-P-K value by chemical fertilizer at the concentration of 20-8-20. Treatment 3 was the mixture of the centrifuged residue and swine manure in the proportion of 1:1. And Treatment 4 was the control set.

Height Comparison among 4 Treatments

From Figure 4-9 and Table 4-8 showing young Para rubber seedling growth measurement results by the height, it was indicated that.

After 15 days, the young rubber plant height of Treatment 2, with the centrifuged residue blended with swine manure and adjusted concentration at 20-8-20 by chemical fertilize changed from 37.05 cm to 40.15 cm. (3.10 cm. taller than the original height). Following was the height of Treatment 1, the chemical fertilizer concentration of 20-8-20, with changing height from 34.57 cm. to 37.25 cm. (0.52 cm. taller than the original height). Lastly, Treatment 3, the mixture of centrifuged residue and swine manure in the proportion of 1:1 with changing height from 40.65 cm. to 41.16 cm. (0.51 cm. taller than the original height). Regarding the statistic test results, it was found that the height in each Treatment had no statistically significant difference at 0.05 levels.

After 30 days, the highest average height of young Para rubber seedling was found in Treatment 2 changing from 40.15 cm. to 43.23 cm. (with height difference of 3.08 cm.). Following was the average height in Treatment1 changing from 37.25 cm. to 39.15 cm. (1.90 cm. taller than original height). As for Treatment 3, the average height changed from 41.16 cm. to 42.74 cm. (with the height difference of 1.58 cm.). Lastly, the average heights of the control set changed from 39.49 cm. to 40.10 cm. (with 0.16 cm. in difference), respectively. Regarding the statistic test results, it was found that the height in each Treatment had no statistically significant difference at 0.05 levels.

At the day 45 of the experiment, the highest average height of young Para rubber seedling was found in Treatment 2 changing from 43.23 cm. to 46.71 cm. (3.48 cm. taller than the original height). Following was the average height in Treatment 1 changing from 39.15 cm. to 40.71 cm. (1.56 cm. taller than the original height). As for Treatment 3, the average height changed from 42.74 cm. to 43.47 cm. (with the difference of 0.73 cm.). Lastly, the average height in the control set changed from 40.10 cm. to 40.44 cm. (0.34 cm. taller than the original height), respectively. Regarding the statistic test results, it was found that the height in each Treatment had no statistically significant difference at 0.05 levels.

After 60 days, the highest average height of young Para rubber seedling was found in Treatment 1 with height changing from 40.71 cm. to 44.89 cm. (4.18 cm. taller than the original height). Following was the average height in Treatment 2 changing from 46.71 cm. to 48.47 cm. (1.76 cm. taller than the original height). The height in Treatment 3 changed from 43.47 cm. to 43.84 cm. (with 0.37 cm. in difference). Lastly, the average height of control set changed from the lowest, 40.44 cm., to 40.67 cm. (0.23 cm. taller than the original height), respectively. Regarding the statistic test results, it was found that the height in each Treatment had no statistically significant difference at 0.05 levels.

After 75 days, the highest average height of young Para rubber seedling was found in Treatment 2 changing from 48.47 cm. to 50.43 cm. (1.96 cm. taller than the original height). Following was the height in Treatment 1 change from 44.89 cm. to 45.89 cm. (1.00 cm. taller than the original height). Treatment 3, the average height changed from 43.84 cm. to 44.57 cm. (with 0.73 cm in difference). Lastly, the control set, height changed from the lowest, 40.67 cm. to 40.94 cm. (0.27 cm. taller than the original height), respectively. Regarding the statistic test results, it was found that the height in each Treatment had no statistically significant difference at 0.05 levels.

After 90 days of determined experiment period, the highest average height of young Para rubber seedling was found in Treatment 1 changing from 45.89 cm. to 46.86 cm. (with 0.97 cm. taller than the original height). Following was the average height in Treatment 2 changing from 50.43 cm. to 51.15 cm. (with 0.72 cm. taller than the original height). The height in Treatment 3 changed from 44.57 cm. to 44.81 cm. (with the difference of 0.24 cm.). Lastly, the height of the control set changed from 40.94 cm. to 41.17 cm. (0.23 cm. taller than the original height), respectively. Regarding the statistic test results, it was found that the height in Treatment 2 was higher than the height in the control set at the statistically significant levels of 0.05.

4.4.2 Trunk Diameter (mm.)

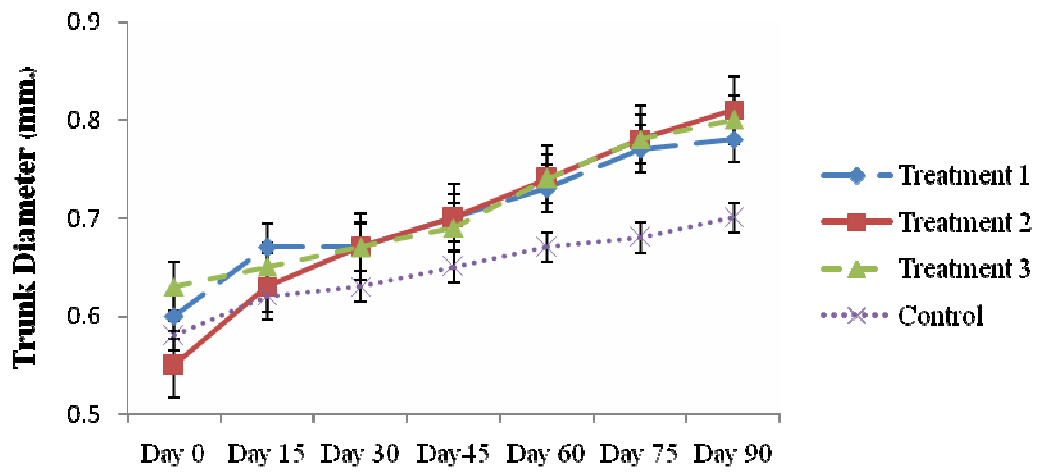


Figure 4-10 Trunk Diameter of Para rubber seedling (cm.)

Table 4-8 Trunk Diameter of Para rubber seedling (mm.)

Treatment No.	P								
	Day 0	Day 15	Day 30	Day 45	Day 60	Day 75	Day 90		
1.	0.60±0.11a ^{1/}	0.67±0.09a ^{1/}	0.67±0.10a ^{1/}	0.70±0.11a ^{1/}	0.73±0.11a ^{1/}	0.77±0.10ab ^{1/}	0.78±0.10ab ^{1/}		
2.	0.55±0.05a	0.63±0.06a	0.67±0.06a	0.70±0.07a	0.74±0.09a	0.78±0.08b	0.81±0.08b		
3.	0.63±0.08a	0.65±0.07a	0.67±0.08a	0.69±0.08a	0.74±0.09a	0.78±0.09b	0.80±0.08b		
Control	0.58±0.10a	0.62±0.11a	0.63±0.10a	0.65±0.10a	0.67±0.11a	0.68±0.11a	0.70±0.13a		

Mean ± SD (n = 15), 1/ = similar English alphabet at the vertical axis showed indifferent value of statistically significant at 0.05 levels by Tukey's HSD method. However, different English alphabets in vertical axis show the difference of statistically significant at 0.05 levels by Tukey's HSD method. If there was more than one alphabet in the vertical axis, for example ab, it means that there was no difference of statistically significant at 0.05 levels from a and b by Tukey's HSD method. Treatment 1 was the chemical fertilizer at the concentration of 20-8-20. Treatment 2 was the mixture of centrifuged residue and swine manure with adjustment of N-P-K value by chemical fertilizer at the concentration of 20-8-20. Treatment 3 was the mixture of the centrifuged residue and swine manure in the proportion of 1:1. And Treatment 4 was the control set.

Comparison of Trunk Diameter among 4 Treatments

Figure 4-10 and Table 4-8 showed the growth development measurement result of trunk diameter of young Para rubber seedling, it showed that after 15 days, the highest trunk diameter measurement value found in Treatment 2, the mixture of centrifuged residue and swine manure with N-P-K adjustment by chemical fertilizer at the concentration of 20-8-20, changed from 0.55 mm. to 0.63 mm. (with 0.08 mm. in difference). Following was the average height in Treatment 1, the chemical fertilizer at the concentration of 20-8-20, changing from .60 mm. to 0.67 mm. (with the difference of 0.04 mm.). Lastly, the height of Treatment 3, the mixture of centrifuged residue and swine manure in the proportion of 1:1, the average of lowest height changed from 0.63 mm. to 0.65 mm. (0.02 mm. taller than the original height), respectively. Regarding the statistic test results, there was no statistically significant difference at 0.05 levels was found in any Treatment.

After 30 days, the highest average trunk diameter found in Treatment 2 changed from 0.63 mm. to 0.67 mm. (with expansion of 0.04 mm.). Following was Treatment 3 changing from 0.65 mm. to 0.67 mm. (with expansion of 0.02.). As for the control set, the trunk diameter changed from 0.62 mm. to 0.63 mm. (with expansion of 0.01 mm.). Lastly, there was no expansion of trunk diameter was found in Treatment 1, respectively. Regarding the statistic test results, there was no statistically significant difference at 0.05 levels was found in any Treatment.

After 45 days, the highest average trunk diameter found in Treatment 1 and Treatment 2 at the equivalent changed from 0.67 mm. to 0.70 mm. (with expansion of 0.03 mm.). Following was the trunk diameter in Treatment 3 and the control set at the equivalent change from 0.67 mm. and 0.63 mm. to 0.69 mm. and 0.65 mm. (with expansion of 0.02 mm.), respectively. Regarding the statistic test results, there was no statistically significant difference at 0.05 levels was found in any Treatment.

After the 60 days period, the highest average trunk diameter found in Treatment 3 changed from 0.69 mm. to 0.74 mm. (with expansion of 0.05 mm.). Following was the diameter in Treatment 2 changing from 0.70 mm. to 0.74 mm. (with expansion of 0.04 mm.). As for Treatment 1, the trunk diameter changed from 0.70 mm. to 0.73 mm. (with the expansion of 0.03 mm.). The control set, the lowest

trunk diameter, changed from 0.65 mm. to 0.67 mm. (with expansion of 0.02 mm.) respectively. Regarding the statistic test results, there was no statistically significant difference at 0.05 levels was found in any Treatment.

After 75 days period, the average trunk diameter of young rubber plant in Treatment 1, Treatment 2 and Treatment 3 expanded equally at 0.04 mm. Trunk diameter in Treatment 1 changed from 0.73 mm. to 0.77 mm., Treatment 2 from 0.74 mm. to 0.78 mm. and Treatment 3 from 0.74 mm. to 0.78 mm. For the control set, the lowest trunk diameter changed from 0.67 mm. to 0.68 mm. with the expansion of 0.01 mm., respectively. Regarding the statistically test results, the average trunk diameter found of Treatment 2 and Treatment 3 were larger than the control set with statistically significant levels at 0.05. However, the comparison of trunk diameter expansion between Treatment 2 and Treatment 3 to dominance set, Treatment 2 was higher than the Treatment 3.

After 90 days experiment period, the highest average trunk diameter found in Treatment 2 changed from 0.78 mm. to 0.81 mm. with expansion of 0.03 mm. Following were Treatment 3 and the dominance set with the equivalent expansion of 0.02 mm. changing from 0.78 mm. to 0.80 mm. and 0.68 mm. to 0.70 mm., respectively. In Treatment 1, the lowest average trunk diameter changed from 0.77 mm. to 0.78 mm. with 0.01 mm. expansion. Regarding the statistically test results, the average trunk diameter of Treatment 2 and Treatment 3 were higher than the control set with statistically significant levels at 0.05. However, the comparison of trunk diameter expansion between Treatment 2 and Treatment 3 to the control set, Treatment 2 was higher than Treatment 3.

4.4.4 Average Number of leaves (Leaf)

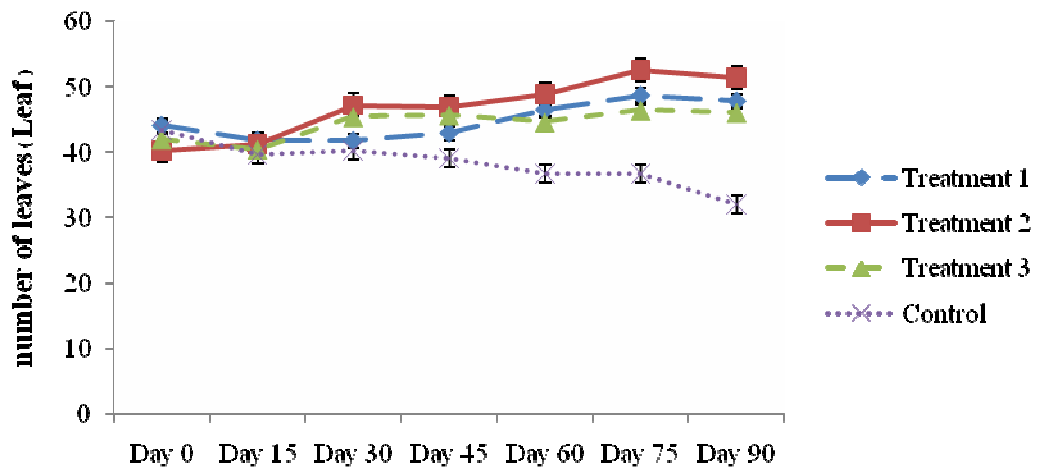


Figure 4-11 The average number of leaves of Para rubber seedling (cm.)

Table 4-9 The average number of leaves of Para rubber seedling (mm.)

Treatment No.	Day 0	Day 15	Day 30	Day 45	Day 60	Day 75	Day 90
1.	44.07±5.46a ^{1/}	41.80±7.41a ^{1/}	41.73±8.66a ^{1/}	42.93±8.82a ^{1/}	46.47±13.42ab ^{1/}	48.67±14.38ab ^{1/}	47.80±14.37b ^{1/}
2.	40.27±6.55a	41.27±10.37a	47.20±11.03a	46.93±11.31a	48.87±12.77b	52.60±17.30b	51.40±16.48b
3.	42.00±8.59a	40.47±8.37a	45.40±12.12a	45.67±13.17a	44.60±12.04ab	46.40±11.39ab	46.07±11.41ab
Control	43.33±6.67a	39.60±7.08a	40.27±8.79a	39.07±8.59a	36.67±9.00a	36.67±7.95a	32.07±7.65a

Mean ± SD (n = 15), 1/ = similar English alphabet at the vertical axis showed indifferent value of statistically significant at 0.05 levels by Tukey's HSD method. However, different English alphabets in vertical axis showed the difference of statistically significant at 0.05 levels by Tukey's HSD method. If there was more than one alphabet in the vertical axis, for example ab, it meant that there was no difference of statistically significant at 0.05 levels from a and b by Tukey's HSD method. Treatment 1 was the chemical fertilizer at the concentration of 20-8-20. Treatment 2 was the mixture of centrifuged residue and swine manure with adjustment of N-P-K value by chemical fertilizer at the concentration of 20-8-20. Treatment 3 was the mixture of the centrifuged residue and swine manure in the proportion of 1:1. And Treatment 4 was the control set.

Comparisons of Number of leaves among 4 Treatments.

Figure 4-11 and Table 4-9 showed the measurement of young Para rubber seedling growth development by leaf number count. It was found that.

After 15 days, the number of leave of young rubber plant in Treatment 2, the mixture of centrifuged residue and swine manure with adjustment of N-P-K value by chemical fertilizer at the concentration of 20-8-20, were the highest average changing from 40.27 to 41.27, (with the increase of leaf as 1.00). Following was Treatment 3, the mixture of centrifuged residue and swine manure in the proportion of 1:1, with the average leaf number count changing from 42.00 to be 40.47 (with the average leaf decrease of 1.53). For Treatment 1, the chemical fertilizer at the concentration of 20-8-20, the leaf number count changed from 44.07 to 41.80 (with the average leaf decrease of 2.27). Lastly, the lowest leaf number count for the control set changed from 43.33 to be 39.60 (with the average leaf decrease of 3.73), respectively. Regarding the statistic test results, there was no statistically significant difference at 0.05 levels was found in any Treatment.

After 30 days, the average number of leaves in Treatment 2 was the highest the average leaves increased from 41.27 to 47.20 with the average leaf increase of 5.93. Following were in Treatment 3, from 40.47 leaves to 45.40 (with the average increase of 4.93) and the control set from 39.60 to 40.27 (with average increase of 0.67). Lastly, Treatment 1, the average number of leaves decreased from 41.80 to 41.73 (with the lowest average decrease of 0.07). Regarding the statistic test results, there was no statistically significant difference at 0.05 levels was found in any Treatment.

After 45 days, the average leaf number count in Treatment 1 was the highest increase from 41.73 to 42.93 (with the average leaf increase of 1.20). Following were in Treatment 3 from 45.40 to 45.67 (with an average leaf increase of 0.27). For Treatment 2 and the control set the average number of leaves decreased from 47.20 to 46.93 (with an average leaf decrease of 0.27) and from 40.27 to 39.07 (with an average leaf decrease of 1.20), respectively. Regarding the statistic test results, there was no statistically significant difference at 0.05 levels was found in any Treatment.

After 60 days, the average leaf number count in Treatment 1 was the highest the average number of leaves increased from 42.93 to 46.47 (with an average leaf increase of 3.54). Following was in Treatment 2 increase from 46.93 to 48.87 (with an average leaf increase of 1.94). For Treatment 3 and the control set the average number of leaves decreased from 45.67 to 44.60 (with an average leaf decrease of 1.07) and from 39.07 to 36.67 (with the lowest average leaf decrease of 2.40), respectively. Regarding the statistically test results, it was found that the average leaf number count in Treatment 2 was higher than the count in the control set with the statistically significant levels at 0.05.

After 75 days, the average leaf number count in Treatment 2 was the highest leaf increase from 48.87 to 52.60 (with an average leaf increase of 3.73). Following were in Treatment 1 increase from 46.47 to 48.67 (with an average leaf increase of 2.20), Treatment 3 from 44.60 to 46.40 (with an average increase of 1.80), respectively. For the control set, there was no change in leaf number count was found. Regarding the statistically test results, it was found that the average leaf number count in Treatment 2 was higher than the control set with the statistically significant levels at 0.05.

After completing 90 days experiment period, it was found that there was an average decrease of number of leaves in all Treatments. The lowest decrease of leaf number count was found in Treatment 3 decrease from 46.40 to 46.07 (with an average leaf decrease of 0.33). Following were in Treatment 1 from 48.67 to 47.80 (with an average leaf decrease of 0.87), Treatment 2 from 52.60 to 51.40 (with an average leaf decrease of 1.20), and lastly, the control set from 36.67 to 32.07 (with the highest decrease leaf number of 4.60), respectively.

Regarding the statistically test results, it was found that Treatment 1 and Treatment 2 had higher leaf number count than the control set with statistically significant levels at 0.05. However, the comparison of leaf number count among Treatment 1 and Treatment 2 to control set, Treatment 1 was higher than the Treatment 2.

CHAPTER V

CONCLUSIONS AND DISCUSSIONS

The study regarding the utilization of the blended fertilizer of the centrifuged residue from rubber latex and swine manure for the growth enhancement of Para seedling could be concluded and discussed as follows.

5.1 Characteristics of soil, Centrifuged Residue from Rubber Latex and Swine Manure before Experiment

The soil for this research was Krabi Series (Kbi) which typically contained high acidity with low organic matter. The electrical conductivity was found at low level and does not harmful to plant. Total Nitrogen, available Phosphorus, exchangeable Potassium, cation exchange capacity were also at low level and percent age of base saturation (%B.S.) was found at very low level.

5.1.1 Centrifuged residue was the solid waste derived from the Para rubber latex processing. Its color was white or pale yellow with sour-smell. As solid waste material, it contained with variety of adulterants such as dust, bark, remnants of leaves, sand, etc. Centrifuged residue from rubber latex was slightly alkaline and its electrical conductivity level was not harmful to plants. Soil organic matter, Total Nitrogen, available Phosphorus, exchangeable Potassium was found at very high level. Only the cation exchange capacity was at moderate level while %B.S. was found at very high level. The result gained from this study was agreed with the research of Phonphan (2004) which found that pH of centrifuged residue was slightly alkaline; available Phosphorous and exchangeable Potassium was extremely high as well. While Krowttikunrungsri (2007) stated that the centrifuged residue derived from each factory would have distinct characteristics due to various factors e.g. the rubber plant variety, soil condition and fertility of planting location, season, etc.

5.1.2 The swine manure from farm without Sodium Hydroxide application was soft chunk, stinking and contained with undigested fiber such as hard part, fiber or those digestible but not absorbable besides, it composed of elements discharged from animal body, especially alimentary canal e.g. intestinal lining, mucous membranes, nutrients, bacteria, and by-product of bacteria (Mala,2003). Regarding the swine manure characteristics, it was slightly alkaline while the electrical conductivity level was moderate. Organic matters, total nitrogen, available phosphorus, exchangeable potassium, were extremely high. The cation exchange capacity and %B.S. were also high. Osotspa, Y. *et al* (2008) and Mala, T. *et al* (2003) said that chemical properties of swine manure derived from each local were different according to the quality of animal feeds, environmental culture and location, age of swine and the swine manure keeping condition; etc. For the electrical conductivity level, it was found at moderate level that had influences to many kind of plants. However, the swine manure only 0.01g. was added for this experiment, therefore, it was not effect to Para rubber seedling as more detail in item 5.5

5.2 Soil Characteristics after Experiment

5.2.1 Regarding soil pH after centrifuged residue introduced, all treatments had higher acid its performance which Kangpidsadarn *et al* (2007b) stated that suitable soil for Para rubber seedling, pH range should be in between 4.5-5.5. Actually, soil pH does not directly affect to the Para rubber seedling, but directly affect to its soluble capability and soil nutrient availability. Therefore, it could be concluded that the Para rubber seedling is capable to adapt it self to such soil conditions.

5.2.2 According to the study result of electrical conductivity of soil after experiment, all treatments contained the soil salinity at low level. Hereof, the electrical conductivity did not affect to plants.

5.2.3 The organic matter contents after centrifuged residue introduced, all treatments had organic matters at low level and the result was in line with Yongyuth *et al* (1998) mentioned that lost of organic matters in soil by leaching was rather slightly found comparing to those lost from decomposition by microorganism. However, changes of organic matters in treatment 2 the mixture of centrifuged residue and swine manure in proportion of 1:1 adjusted N-P-K elements with chemical substance for the concentration of 20-8-20, and treatment 3, the mixture of centrifuged residue and swine manure in the proportion of 1:1 were different to those of treatment 1, the chemical fertilizer formula 20-8-20, and the control set at significantly statistical difference 0.05.

5.2.4 The findings of soil nutrient found that Total Nitrogen (TKN) for all treatment was low with no significant difference at 0.05. Furthermore, soil drainage characteristic of Krabi soil series (Kbi) is well and Yongyuth *et al*. (2008) mentioned that soil with such characteristics had a change to lose Nitrogen in the form of gas of Nitrogen fertilizer only 1-3%. The result was agreed with the studies of Li *et al* (2010) and Huang *et al* (2004) which mentioned that TKN lost by dissolving of water could occasion ally occur due to the fact that surplus of water flowing through soil could leach soil nutrients.

5.2.5 The result of available Phosphorus in soil after experiment found that treatment 1, the chemical fertilizer formula 20-8-20, contained the available Phosphorus at the highest level since treatment 1 was added with available Phosphorus in form of chemical fertilizer and resulted to the available Phosphorus was found at high level. For Treatment 2, the mixture of centrifuged residue and swine manure in proportion of 1:1 adjusted N-P-K elements with chemical substance for the concentration of 20-8-20, the available Phosphorus was found at lower level than Treatment 1. Actually, the available Phosphorus of Treatment 1 and 2 were equivalent at beginning of the experiment. The reason was that the Para rubber seedling growth development in Treatment 2 was higher than Treatment 1. Treatment 3, the mixture of centrifuged residue and swine manure in the proportion of 1:1, contained available

Phosphorus at low level and in the control set was rarely detected to any value. Besides, soil in each treatment was of extremely high acidity and less was remained for plant utilization. Yongyuth *et al* (2008) mentioned that such condition caused the activity of Phosphate fixing in form of iron and aluminum which were difficult to dissolve in water.

5.2.6 The result of exchangeable Potassium after experiment found that treatment 1, the chemical fertilizer formula 20-8-20, contained exchangeable Potassium at low level. While those in treatment 2, the mixture of centrifuged residue and swine manure in proportion of 1:1 adjusted N-P-K elements with chemical substance for the concentration of 20-8-20, treatment 3, the mixture of centrifuged residue and swine manure in the proportion of 1:1, and the control set were found at very low level.

5.2.7 The result of cation exchange capacity (CEC) found that all treatments had CEC values at low level. However, CEC in each treatment was more than in the control set with significantly statistical difference level 0.05.

5.2.8 The result of %BS found that all treatments had high level of base saturation values.

5.3 Nutrient leachate

For the analysis of nutrient leachate, the procedure was analyzed for every 15 days to investigate the losing nutrient during the experiment. Considering through the time frame, all treatments were found that pH, EC, Total Nitrogen, available Phosphorus, exchangeable Potassium, gradually descended in values. Upon nutrient uptake by plants, Total Nitrogen, available Phosphorus, exchangeable Potassium leaching by water descended in values (Momngam, 2004) as well as pH and EC value were also decreased. The result was agreed with the former report which presented that while plant was absorbed nutrients, pH and EC of soil was relatively decreased.

5.4 Para Rubber seedling growths

The study of Para rubber seedling growth was done by measuring at 3 cm. above grafted-bud mark for every 15 day, throughout 90 days. The growth was considered through height (cm.), trunk diameter (cm.) and number of leaves. The conclusion was as follows.

5.4.1 Height

The result found that treatment 2, the mixture of centrifuged residue and swine manure in proportion of 1:1 adjusted N-P-K elements with chemical fertilizer for the concentration of 20-8-20 resulted to the height differences among young Para rubber seedling at 75 and 90 day comparing with the control set at the significantly statistical difference at the level of 0.05. Treatment 2, plant had the highest effect on height followed by treatment 1, the chemical fertilizer formula 20-8-20, and treatment 3 the mixture of centrifuged residue and swine manure were mixed in the proportion of 1:1, respectively. For the control set, the Para rubber seedling had the lowest height.

5.4.2 Trunk Diameter

The research result found that treatment 2 the mixture of centrifuged residue and swine manure in proportion of 1:1 adjusted N-P-K elements with chemical fertilizer for the concentration of 20-8-20 affected to the trunk diameter of young Para rubber seedling at the day 75 and 90 with the control set at the statistically significance difference at 0.05. That was resulted to treatment 2 had the trunk diameter of young Para rubber seedling, followed by treatment 3, the mixture of centrifuged residue and swine manure in the proportion of 1:1, and treatment 1, the chemical fertilizer formula 20-8-20, respectively. For the control set, it had the lowest height of Para rubber seedling.

5.4.3 Number of leaves

The findings found that treatment 2 had the most affects to the number of leaves of Para rubber seedling at the days 60, 75 and 90. The result was different from the control set with statistically significant difference at level of 0.05. In other words,

treatment 2, the mixture of centrifuged residue and swine manure in proportion of 1:1 adjusted N-P-K elements with chemical substance for the concentration of 20-8-20 mostly influences to the number of leaves of Para rubber seedling. The result did not difference from treatment 1, the chemical fertilizer formula 20-8-20, and treatment 3, the mixture of centrifuged residue and swine manure in the proportion of 1:1, respectively. The control set had the least affect on number of leaves of Para rubber seedling.

From all experiments, it could be summarized that the utilization of the blended centrifuged residue from Para rubber latex and swine manure with chemical fertilizer was mostly influenced to the Para rubber seedling growth comparing to the control set. The utilization of only chemical fertilizer was the second effect to Para rubber seedling growth the result was agreed with the studies of XU *et al.* (2008) and Damodar *et al.* (2000) which conducted the impact assessment regarding utilization of swine manure and chemical fertilizer. They found that utilization of swine manure and chemical fertilizer or only swine manure would enhance soil nutrients and soil fertility. Furthermore, it was suggested to be an alternative practice for environmental pollution management.

5.5 Actual Utilization of Blended Fertilizer (Treatment 2)

All fertilizer formula for this research experiment was added with blended fertilizer into the Para rubber seedling for 5 g/plant. Therefore, the retrospective calculation could be substituted with the blended fertilizer in actual location as follows:

$$\begin{aligned}
 1 \text{ rai of area} &= 1,600 \text{ m}^2 \\
 &= 1,600 \times 10,000 \text{ cm}^2 \\
 \text{Soil depth} &= 30 \text{ cm.} \\
 \text{Soil density} &= 1.111 \text{ g/ cm}^3 \\
 \text{Therefore soil for 1 rai weighed} & \\
 &= 1,600 \times 10,000 \text{ cm}^2 \times 30 \text{ cm.} \times 1.111 \text{ g/ cm}^3 \\
 &= 533,280,000 \text{ g.}
 \end{aligned}$$

Soil for the experiment weighted 9,000 g/bag substituting as follows:

Soil in the experimental bag weighted 9,000 g. mixed with 5 g. of blended fertilizer. Then, soil for 1 rai weighed 533,280,000 g., the fertilizer to be added

$$= (533,280,000 \text{ g} \times 5\text{g}) / 9,000 \text{ g}$$

$$= 296,266.67 \text{ g or } 296.27 \text{ kg. /rai}$$

In treatment 2 was the centrifuged residue and swine manure in proportion of 1:1 adjusted by N-P-K elements with chemical substance for the concentration of 20-8-20. It had 5g./plant (in the experiment). The designed fertilizer composed of centrifuged residue and swine manure for 0.01g. each, Urea fertilizer at 0.46g., diammonium phosphate fertilizer at 1.37g. and potassium chloride fertilizer at 1.37g. The retrospective calculation could be substituted with the blended fertilizer in actual location as follows:

Swine manure and centrifuged residue

Soil in the experimental bag weighted 9,000 g. added with swine manure and centrifuged residue for 0.01 g. of each fertilizer.

Then, soil for 1 rai weighted 533,280,000 g., the amount of each fertilizers (swine manure and centrifuged residue)

$$= (533,280,000 \text{ g} \times 0.01\text{g}) / 9,000 \text{ g}$$

$$= 592.53 \text{ g or } 0.59 \text{ kg. /rai}$$

Urea fertilizer

Soil in the experimental bag weighted 9,000 g. added with urea fertilizer 0.46 g.

Then, soil for 1 rai weighted 533,280,000 g., the amount of urea fertilizer to be added

$$= (533,280,000 \text{ g} \times 0.46\text{g}) / 9,000 \text{ g}$$

$$= 27,256.53 \text{ g or } 27.26 \text{ kg. /rai}$$

Diammonium phosphate fertilizer

Soil in the experimental bag weighted 9,000 g. added with diammonium phosphate fertilizer at 1.37 g.

Then, soil for 1 rai weighted 533,280,000 g., the amount of diammonium phosphate fertilizer to be added

$$\begin{aligned} &= (533,280,000 \text{ g} \times 1.37\text{g}) / 9,000 \text{ g} \\ &= 81,177.07 \text{ g or } 81.18 \text{ kg. /rai} \end{aligned}$$

Potassium chloride fertilizer

Soil in the experimental bag weighted 9,000 g. added with potassium chloride fertilizer at 3.15 g.

Then, soil for 1 rai weighted 533,280,000 g., the amount of potassium chloride fertilizer to be added

$$\begin{aligned} &= (533,280,000 \text{ g} \times 3.15\text{g}) / 9,000 \text{ g} \\ &= 186,648 \text{ g or } 186.65 \text{ kg. /rai} \end{aligned}$$

5.6 Recommendations for future study

1. The fertilizer formula 20-8-20 is widely used for Para rubber seedling plot, bud-grafted plot and Para rubber before latex tapping. However, fertilizer quantity application is different according to age of Para rubber planting. It is suggested for future study to pay more attention on appropriate quantity of fertilizer against age of plant.

2. The Para rubber seedling selection, the amount of leaf storey should be the same in order to avoid the difference of initial sprout growth of Para rubber seedling.

3. The swine manure to be used as fertilizer for plant should be leave in the open air area for 20-30 days in order to decompose organic matter to be as inorganic substance which is not harmful to plant.

4. This research was the experiment in laboratory scale in the open air ground, so it was difficult to control sunlight, temperature, moisture, etc. Therefore, the next experiment should consider about experiential house that all factors can be controlled.

REFERENCES

- Damodar Reddy, D., Subba Rao, A., Rupa, T.R. 2000. **Effects of continuous use of cattle manure and fertilizer phosphorus on crop yields and soil organic phosphorus in a Vertisol.** *Bioresource Technology* 75, 113-118.
- Dea, G.B., Assiri, A.A., Gabla, O.R., Boa, D. 2001. **Influence of soil preparation method on root and vegetative growth of rubber tree (*Hevea brasiliensis*) in the southwest Côte d'Ivoire.** *Soil and Tillage Research* 59: 3-11.
- Department of Industrial Works. **Industrial sector codes of Practice for Cleaner Technology.** Department of Industrial Works. Bangkok.
- Department of Environmental Quality Promotion, 2006. **Survey of Natural Resources and Environment manual.** Faculty of Environment and Resource Studies. Mahidol University. Bangkok.
- Evanylo, G., Sherony, C., Spargo, J., Starner, D., Brosius, M., Haering, K. 2008. **Soil and water environmental effects of fertilizer-, manure-, and compost-based fertility practices in an organic vegetable cropping system.** *Agriculture, Ecosystems & Environment* 127: 50-58.
- Gil, M.V., Calvo, L.F., Blanco, D., Sánchez, M.E. 2008. **Assessing the agronomic and environmental effects of the application of cattle manure compost on soil by multivariate methods.** *Bioresource Technology* 99: 5763-5772.
- <http://www.oae.go.th/statistic/import/imFTZ.xls>. [22 September 2008]
- [http://www.ldd.go.th/Lddwebsite/web osl/soilgr man/south/pdf s/book/srt.pdf](http://www.ldd.go.th/Lddwebsite/web%20osl/soilgr%20man/south/pdf%20s/book/srt.pdf). [15 October 2008]
- Huang, G.F., Wong, J.W.C., Wu, Q.T., Nagar, B.B., 2004. **Effect of C/N on composting of pig manure with sawdust.** *Waste Management* 24: 805-813.

- Kangpidsadarn, N. 2007a. **Efficiency of rubber fertilizer** : Training documents for new employees; Office of the rubber replanting Aid Fund 27 – 29 August 2007 at the Maritime Park & Spa Resort, Krabi. Rubber Research Institute of Thailand. Bangkok.
- Kangpidsadarn, N. 2007b. **Technology development to reduce the time before the draw rubber tree**. The full research report annual 2007. Rubber Research Institute of Thailand; Ministry of Agriculture and Cooperatives. Bangkok.
- Keawruenrom, E. 2004. **Manual interaction of soil survey**. Department of Soil Science, Faculty of Agriculture, Kasetsart University. Bangkok. 182 p.
- Krowuttikunrungsri, S. http://rubber.sc.mahidol.ac.th/RTUinfo/research/latex_2-5.htm. [22 December 2007]
- Land Development Department Bureau of Land Sciences. 2005. **Manual analysis of sample Soil, water, fertilizer, soil amendments and plant analysis to verify certification**. Land Development Department; Ministry of Agriculture and Cooperatives. Bangkok.
- Li, Z., Liu, M., Wu, X., Han, F., Zhang, T. 2010. **Effects of long-term chemical fertilization and organic amendments on dynamics of soil organic C and total N in paddy soil derived from barren land in subtropical China**. Soil and Tillage Research 106: 268-274.
- Mala, T.*et al* 2003. **Organic fertilizer and Bio fertilizer; Application and Production Techniques**. Kasetsart University. Bangkok. 450 p.
- Momngam, W. 2004. **Effect of swine Waste Extract in Foliar Application on Cassava Yield, Starch Content and Nutritional Values of Cassava Chips**. Unpublished M Sc. (Economic Botany), Major Field: Economic Botany, Division of Science. Kasetsart University. Bangkok. 145 p.
- Office of the Rubber Replanting Aid Fund. **Rubber cultivation in new areas**. Ministry of Agriculture and Cooperatives. Bangkok.
- Osotspa, Y.*et al*. 1998. **Introduction to Soil Science**. Department of Soil Science, Faculty of Agriculture. Kasetsart University. Bangkok 547 p.
- Osotspa, Y.*et al*. 2008. **Fertilizers for Sustainable Agriculture**. Department of Soil Science, Faculty of Agriculture at Kamphaeng Saen, Kasetsart University. Bangkok. 519 p.

- Okieimen, C.O., Okieimen, F.E., 2002. **Effect of natural rubber processing sludge on the degradation of crude oil hydrocarbons in soil.** Bioresource Technology 82: 95-97.
- Phonphan, W. 2004. Utilization of the lutoid of rubber latex industry in term of soil conditioner. Unpublished M Sc. (Inter-Department), Chulalongkorn University. 135 p.
- Pollution Control Department, Bangkok.** [http:// www. pcd. go. Th /info_serv/water_swine.html.](http://www.pcd.go.th/info_serv/water_swine.html) [24 May 2008]
- Potiwadtuthum, S.*et al.* 2010. **Effect of soil Conditioner and organic Fertilizer with Chemical Fertilizer on Yield of Rubber Grown in Ustic Moisture Regime.** Rubber Research Songkhla Rubber Research and Development and Rubber Research Institute of Thailand; Ministry of Agriculture and Cooperatives. Bangkok.
- Rubber Research Institute of Thailand. 2007. การสร้างแปลงกิ่งตายน การสร้างแปลงกล้าตาย การตัดตายน. Rubber Research Institute of Thailand; Ministry of Agriculture and Cooperatives. Bangkok.
- Rubber Research Institute of Thailand. 2007a. **Technical document : Use of fertilizers and rubber plantation maintenance.** Rubber Research Institute of Thailand; Ministry of Agriculture and Cooperatives. Bangkok.
- Rubber Research Institute of Thailand. 2007b. **Recommendations for Rubber plantation.** Rubber Research Institute of Thailand; Ministry of Agriculture and Cooperatives. Bangkok.
- Rubber Research Institute of Thailand. 2010. **Thai Rubber Statistics.** [http://www.rubberthai.com.](http://www.rubberthai.com) [24 July 2008]
- Rubber Research Institute of Thailand. 2010. **Technical rubber.** Rubber Research Institute of Thailand; Ministry of Agriculture and Cooperatives. Bangkok.
- Rubber Research Institute of Thailand. **The standard rubber tree plant.** Brochure published.
- Rutthanalum, J.2008.[http://www.agri.ubu.ac.th/seminar/masterstu/Swine_Manure.htm.](http://www.agri.ubu.ac.th/seminar/masterstu/Swine_Manure.htm) [30 October 2008]

- Sangvatin, M. 2008. **Rubber plantations handbook**. Kasetsiambook Publishers. Bangkok. 160 p.
- Sasangta, P. 2000. **A use of dried house fly larva form pig manure in substitution of fish meal for first stage broiler**. Unpublished M Sc. (Appropriate Technology for Resource and Environmental Development), Mahidol University. 91 p
- Suchard, S. 2005. **Natural Rubber**. Faculty of Science and Technology. Prince of Songkla University. Pattani Campus
- Suwanmongkorn, P. 1998. **Study the use of organic fertilizer with chemical fertilizer that effect. Growth of young rubber trees in a climate that: Rubber Research Nong Khai Rubber Research and Development**. Report of the Rubber Research and Development Annual 2541. Rubber Research Institute of Thailand; Ministry of Agriculture and Cooperatives. Bangkok.
- Teerajindakajorn, P. *et al.* 2010. **Assessment of soil fertility by soil analysis**. Department of Plant Science and Agricultural Resources. Faculty of Agriculture. Khon Kaen University. 37p
- Tekprasit, V. 1999. **The Utilization of the Centrifuged Residue from Concentrated Latex Industry as a Soil Conditioner**. Unpublished M Sc. (Environmental Management), Prince of Songkla University. Songkla. 169p.
- Ubon, V. *et al.* 2010. **Potential of Organic Residues from Concentrated Latex, Fish Processing and PalmOil Industries in the Preparation of Planting Materials for Garden Grass**. <http://mapserv.agri.ubu.ac.th/Data/rubber/resrubber.html>. [30 August 2010].
- Wansiri, S. 2006. **Para Rubber**. Publisher agricultural base. Bangkok. 78 p.
- Xu, M.-g., Li, D.-c., Li, J.-m., Qin, D.-z., Kazuyuki, Y., Hosen, Y. 2008. **Effects of Organic Manure Application with Chemical Fertilizers on Nutrient Absorption and Yield of Rice in Hunan of Southern China**. Agricultural Sciences in China 7, 1245-1252.
- Zhang, H., Zhang, G.-L., Zhao, Y.-G., Zhao, W.-J., Qi, Z.-P., 2007. **Chemical degradation of a Ferralsol (Oxisol) under intensive rubber (Hevea**

brasiliensis) farming in tropical China. Soil and Tillage Research 93:
109-116.

APPENDICES

APPENDIX A

STATISTICS USED IN THIS RESEARCH

ผลการวิเคราะห์ข้อมูลดินหลังการทดลอง

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
pH	Between Groups	.746	3	.249	13.072	.000
	Within Groups	1.066	56	.019		
	Total	1.812	59			
EC	Between Groups	16087.683	3	5362.561	24.302	.000
	Within Groups	12357.156	56	220.664		
	Total	28444.840	59			
TKN	Between Groups	.001	3	.000	.931	.432
	Within Groups	.011	56	.000		
	Total	.012	59			
P	Between Groups	14028.672	3	4676.224	657.455	.000
	Within Groups	398.307	56	7.113		
	Total	14426.978	59			
K	Between Groups	4192.730	3	1397.577	175.750	.000
	Within Groups	445.316	56	7.952		
	Total	4638.046	59			
OM	Between Groups	.160	3	.053	9.145	.000
	Within Groups	.327	56	.006		
	Total	.487	59			
CEC	Between Groups	1.748	3	.583	20.922	.000
	Within Groups	1.560	56	.028		
	Total	3.308	59			
BS	Between Groups	734220.5	3	244740.173	23.761	.000
	Within Groups	576807.6	56	10300.136		
	Total	1311028	59			

Post Hoc Tests

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
pH	Treatment 1	Treatment 2	-.25400*	.05037	.000	-.3874	-.1206
		Treatment 3	-.23400*	.05037	.000	-.3674	-.1006
		Control	-.27733*	.05037	.000	-.4107	-.1440
	Treatment 2	Treatment 1	.25400*	.05037	.000	.1206	.3874
		Treatment 3	.02000	.05037	.979	-.1134	.1534
		Control	-.02333	.05037	.967	-.1567	.1100
	Treatment 3	Treatment 1	.23400*	.05037	.000	.1006	.3674
		Treatment 2	-.02000	.05037	.979	-.1534	.1134
		Control	-.04333	.05037	.825	-.1767	.0900
	Control	Treatment 1	.27733*	.05037	.000	.1440	.4107
		Treatment 2	.02333	.05037	.967	-.1100	.1567
		Treatment 3	.04333	.05037	.825	-.0900	.1767
EC	Treatment 1	Treatment 2	8.46667	5.42419	.409	-5.8960	22.8293
		Treatment 3	11.52667	5.42419	.158	-2.8360	25.8893
		Control	43.20133*	5.42419	.000	28.8387	57.5640
	Treatment 2	Treatment 1	-8.46667	5.42419	.409	-22.8293	5.8960
		Treatment 3	3.06000	5.42419	.942	-11.3026	17.4226
		Control	34.73467*	5.42419	.000	20.3720	49.0973
	Treatment 3	Treatment 1	-11.52667	5.42419	.158	-25.8893	2.8360
		Treatment 2	-3.06000	5.42419	.942	-17.4226	11.3026
		Control	31.67467*	5.42419	.000	17.3120	46.0373
	Control	Treatment 1	-43.20133*	5.42419	.000	-57.5640	-28.8387
		Treatment 2	-34.73467*	5.42419	.000	-49.0973	-20.3720
		Treatment 3	-31.67467*	5.42419	.000	-46.0373	-17.3120
TKN	Treatment 1	Treatment 2	-.00800	.00513	.410	-.0216	.0056
		Treatment 3	-.00333	.00513	.915	-.0169	.0103
		Control	-.00133	.00513	.994	-.0149	.0123
	Treatment 2	Treatment 1	.00800	.00513	.410	-.0056	.0216
		Treatment 3	.00467	.00513	.800	-.0089	.0183
		Control	.00667	.00513	.568	-.0069	.0203
	Treatment 3	Treatment 1	.00333	.00513	.915	-.0103	.0169
		Treatment 2	-.00467	.00513	.800	-.0183	.0089
		Control	.00200	.00513	.980	-.0116	.0156
	Control	Treatment 1	.00133	.00513	.994	-.0123	.0149
		Treatment 2	-.00667	.00513	.568	-.0203	.0069
		Treatment 3	-.00200	.00513	.980	-.0156	.0116

ผลการวิเคราะห์ข้อมูลน้ำระหว่างการทดลอง

ค่า pH น้ำ

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Day_0	Between Groups	.347	3	.116	910.797	.000
	Within Groups	.007	56	.000		
	Total	.354	59			
Day_15	Between Groups	.715	3	.238	1475.943	.000
	Within Groups	.009	56	.000		
	Total	.724	59			
Day_30	Between Groups	.896	3	.299	3555.200	.000
	Within Groups	.005	56	.000		
	Total	.901	59			
Day_45	Between Groups	1.070	3	.357	3752.819	.000
	Within Groups	.005	56	.000		
	Total	1.075	59			
Day_60	Between Groups	1.139	3	.380	5315.792	.000
	Within Groups	.004	56	.000		
	Total	1.143	59			
Day_75	Between Groups	2.316	3	.772	2824.374	.000
	Within Groups	.015	56	.000		
	Total	2.331	59			
Day_90	Between Groups	5.211	3	1.737	5360.070	.000
	Within Groups	.018	56	.000		
	Total	5.229	59			

Post Hoc Tests

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Day_0	Treatment 1	Treatment 2	-.02467*	.00411	.000	-.0356	-.0138
		Treatment 3	-.19133*	.00411	.000	-.2022	-.1804
		Control	-.11600*	.00411	.000	-.1269	-.1051
	Treatment 2	Treatment 1	.02467*	.00411	.000	.0138	.0356
		Treatment 3	-.16667*	.00411	.000	-.1776	-.1558
		Control	-.09133*	.00411	.000	-.1022	-.0804
	Treatment 3	Treatment 1	.19133*	.00411	.000	.1804	.2022
		Treatment 2	.16667*	.00411	.000	.1558	.1776
		Control	.07533*	.00411	.000	.0644	.0862
	Control	Treatment 1	.11600*	.00411	.000	.1051	.1269
		Treatment 2	.09133*	.00411	.000	.0804	.1022
		Treatment 3	-.07533*	.00411	.000	-.0862	-.0644
Day_15	Treatment 1	Treatment 2	-.01533*	.00464	.009	-.0276	-.0030
		Treatment 3	-.25200*	.00464	.000	-.2643	-.2397
		Control	-.19067*	.00464	.000	-.2030	-.1784
	Treatment 2	Treatment 1	.01533*	.00464	.009	.0030	.0276
		Treatment 3	-.23667*	.00464	.000	-.2490	-.2244
		Control	-.17533*	.00464	.000	-.1876	-.1630
	Treatment 3	Treatment 1	.25200*	.00464	.000	.2397	.2643
		Treatment 2	.23667*	.00464	.000	.2244	.2490
		Control	.06133*	.00464	.000	.0490	.0736
	Control	Treatment 1	.19067*	.00464	.000	.1784	.2030
		Treatment 2	.17533*	.00464	.000	.1630	.1876
		Treatment 3	-.06133*	.00464	.000	-.0736	-.0490
Day_30	Treatment 1	Treatment 2	-.01133*	.00335	.007	-.0202	-.0025
		Treatment 3	-.26667*	.00335	.000	-.2755	-.2578
		Control	-.23067*	.00335	.000	-.2395	-.2218
	Treatment 2	Treatment 1	.01133*	.00335	.007	.0025	.0202
		Treatment 3	-.25533*	.00335	.000	-.2642	-.2465
		Control	-.21933*	.00335	.000	-.2282	-.2105
	Treatment 3	Treatment 1	.26667*	.00335	.000	.2578	.2755
		Treatment 2	.25533*	.00335	.000	.2465	.2642
		Control	.03600*	.00335	.000	.0271	.0449
	Control	Treatment 1	.23067*	.00335	.000	.2218	.2395
		Treatment 2	.21933*	.00335	.000	.2105	.2282
		Treatment 3	-.03600*	.00335	.000	-.0449	-.0271
Day_45	Treatment 1	Treatment 2	.00333	.00356	.785	-.0061	.0128
		Treatment 3	-.27467*	.00356	.000	-.2841	-.2652
		Control	-.25533*	.00356	.000	-.2648	-.2459
	Treatment 2	Treatment 1	-.00333	.00356	.785	-.0128	.0061
		Treatment 3	-.27800*	.00356	.000	-.2874	-.2686
		Control	-.25867*	.00356	.000	-.2681	-.2492
	Treatment 3	Treatment 1	.27467*	.00356	.000	.2652	.2841
		Treatment 2	.27800*	.00356	.000	.2686	.2874
		Control	.01933*	.00356	.000	.0099	.0288
	Control	Treatment 1	.25533*	.00356	.000	.2459	.2648
		Treatment 2	.25867*	.00356	.000	.2492	.2681
		Treatment 3	-.01933*	.00356	.000	-.0288	-.0099

Day_60	Treatment 1	Treatment 2	-.00733	.00309	.094	-.0155	.0008
		Treatment 3	-.29067*	.00309	.000	-.2988	-.2825
		Control	-.26667*	.00309	.000	-.2748	-.2585
	Treatment 2	Treatment 1	.00733	.00309	.094	-.0008	.0155
		Treatment 3	-.28333*	.00309	.000	-.2915	-.2752
		Control	-.25933*	.00309	.000	-.2675	-.2512
	Treatment 3	Treatment 1	.29067*	.00309	.000	.2825	.2988
		Treatment 2	.28333*	.00309	.000	.2752	.2915
		Control	.02400*	.00309	.000	.0158	.0322
	Control	Treatment 1	.26667*	.00309	.000	.2585	.2748
		Treatment 2	.25933*	.00309	.000	.2512	.2675
		Treatment 3	-.02400*	.00309	.000	-.0322	-.0158
Day_75	Treatment 1	Treatment 2	.01800*	.00604	.021	.0020	.0340
		Treatment 3	-.37867*	.00604	.000	-.3947	-.3627
		Control	-.38867*	.00604	.000	-.4047	-.3727
	Treatment 2	Treatment 1	-.01800*	.00604	.021	-.0340	-.0020
		Treatment 3	-.39667*	.00604	.000	-.4127	-.3807
		Control	-.40667*	.00604	.000	-.4227	-.3907
	Treatment 3	Treatment 1	.37867*	.00604	.000	.3627	.3947
		Treatment 2	.39667*	.00604	.000	.3807	.4127
		Control	-.01000	.00604	.356	-.0260	.0060
	Control	Treatment 1	.38867*	.00604	.000	.3727	.4047
		Treatment 2	.40667*	.00604	.000	.3907	.4227
		Treatment 3	.01000	.00604	.356	-.0060	.0260
Day_90	Treatment 1	Treatment 2	.01133	.00657	.321	-.0061	.0287
		Treatment 3	-.58533*	.00657	.000	-.6027	-.5679
		Control	-.58200*	.00657	.000	-.5994	-.5646
	Treatment 2	Treatment 1	-.01133	.00657	.321	-.0287	.0061
		Treatment 3	-.59667*	.00657	.000	-.6141	-.5793
		Control	-.59333*	.00657	.000	-.6107	-.5759
	Treatment 3	Treatment 1	.58533*	.00657	.000	.5679	.6027
		Treatment 2	.59667*	.00657	.000	.5793	.6141
		Control	.00333	.00657	.957	-.0141	.0207
	Control	Treatment 1	.58200*	.00657	.000	.5646	.5994
		Treatment 2	.59333*	.00657	.000	.5759	.6107
		Treatment 3	-.00333	.00657	.957	-.0207	.0141

*. The mean difference is significant at the .05 level.

ค่า EC น้ำ

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Day_0	Between Groups	8699821	3	2899940.311	595586.8	.000
	Within Groups	272.667	56	4.869		
	Total	8700094	59			
Day_15	Between Groups	7348899	3	2449633.000	592312.0	.000
	Within Groups	231.600	56	4.136		
	Total	7349131	59			
Day_30	Between Groups	4916109	3	1638703.000	361668.6	.000
	Within Groups	253.733	56	4.531		
	Total	4916363	59			
Day_45	Between Groups	4151324	3	1383774.511	266110.5	.000
	Within Groups	291.200	56	5.200		
	Total	4151615	59			
Day_60	Between Groups	3817469	3	1272489.528	375840.8	.000
	Within Groups	189.600	56	3.386		
	Total	3817658	59			
Day_75	Between Groups	2752046	3	917348.733	168027.2	.000
	Within Groups	305.733	56	5.460		
	Total	2752352	59			
Day_90	Between Groups	2335452	3	778484.150	158643.1	.000
	Within Groups	274.800	56	4.907		
	Total	2335727	59			

Post Hoc Tests

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Day_0	Treatment 1	Treatment 2	18.46667*	.80573	.000	16.3332	20.6002
		Treatment 3	56.33333*	.80573	.000	54.1998	58.4668
		Control	903.06667*	.80573	.000	900.9332	905.2002
	Treatment 2	Treatment 1	-18.46667*	.80573	.000	-20.6002	-16.3332
		Treatment 3	37.86667*	.80573	.000	35.7332	40.0002
		Control	884.60000*	.80573	.000	882.4665	886.7335
	Treatment 3	Treatment 1	-56.33333*	.80573	.000	-58.4668	-54.1998
		Treatment 2	-37.86667*	.80573	.000	-40.0002	-35.7332
		Control	846.73333*	.80573	.000	844.5998	848.8668
	Control	Treatment 1	-903.06667*	.80573	.000	-905.2002	-900.9332
		Treatment 2	-884.60000*	.80573	.000	-886.7335	-882.4665
		Treatment 3	-846.73333*	.80573	.000	-848.8668	-844.5998
Day_15	Treatment 1	Treatment 2	680.40000*	.74258	.000	678.4337	682.3663
		Treatment 3	791.80000*	.74258	.000	789.8337	793.7663
		Control	894.86667*	.74258	.000	892.9004	896.8329
	Treatment 2	Treatment 1	-680.40000*	.74258	.000	-682.3663	-678.4337
		Treatment 3	111.40000*	.74258	.000	109.4337	113.3663
		Control	214.46667*	.74258	.000	212.5004	216.4329
	Treatment 3	Treatment 1	-791.80000*	.74258	.000	-793.7663	-789.8337
		Treatment 2	-111.40000*	.74258	.000	-113.3663	-109.4337
		Control	103.06667*	.74258	.000	101.1004	105.0329
	Control	Treatment 1	-894.86667*	.74258	.000	-896.8329	-892.9004
		Treatment 2	-214.46667*	.74258	.000	-216.4329	-212.5004
		Treatment 3	-103.06667*	.74258	.000	-105.0329	-101.1004
Day_30	Treatment 1	Treatment 2	535.20000*	.77726	.000	533.1419	537.2581
		Treatment 3	636.40000*	.77726	.000	634.3419	638.4581
		Control	744.26667*	.77726	.000	742.2086	746.3248
	Treatment 2	Treatment 1	-535.20000*	.77726	.000	-537.2581	-533.1419
		Treatment 3	101.20000*	.77726	.000	99.1419	103.2581
		Control	209.06667*	.77726	.000	207.0086	211.1248
	Treatment 3	Treatment 1	-636.40000*	.77726	.000	-638.4581	-634.3419
		Treatment 2	-101.20000*	.77726	.000	-103.2581	-99.1419
		Control	107.86667*	.77726	.000	105.8086	109.9248
	Control	Treatment 1	-744.26667*	.77726	.000	-746.3248	-742.2086
		Treatment 2	-209.06667*	.77726	.000	-211.1248	-207.0086
		Treatment 3	-107.86667*	.77726	.000	-109.9248	-105.8086
Day_45	Treatment 1	Treatment 2	495.66667*	.83267	.000	493.4619	497.8715
		Treatment 3	597.13333*	.83267	.000	594.9285	599.3381
		Control	675.33333*	.83267	.000	673.1285	677.5381
	Treatment 2	Treatment 1	-495.66667*	.83267	.000	-497.8715	-493.4619
		Treatment 3	101.46667*	.83267	.000	99.2619	103.6715
		Control	179.66667*	.83267	.000	177.4619	181.8715
	Treatment 3	Treatment 1	-597.13333*	.83267	.000	-599.3381	-594.9285
		Treatment 2	-101.46667*	.83267	.000	-103.6715	-99.2619
		Control	78.20000*	.83267	.000	75.9952	80.4048
	Control	Treatment 1	-675.33333*	.83267	.000	-677.5381	-673.1285
		Treatment 2	-179.66667*	.83267	.000	-181.8715	-177.4619
		Treatment 3	-78.20000*	.83267	.000	-80.4048	-75.9952

Day_60	Treatment 1	Treatment 2	478.13333*	.67188	.000	476.3543	479.9124
		Treatment 3	587.53333*	.67188	.000	585.7543	589.3124
		Control	636.26667*	.67188	.000	634.4876	638.0457
	Treatment 2	Treatment 1	-478.13333*	.67188	.000	-479.9124	-476.3543
		Treatment 3	109.40000*	.67188	.000	107.6209	111.1791
		Control	158.13333*	.67188	.000	156.3543	159.9124
	Treatment 3	Treatment 1	-587.53333*	.67188	.000	-589.3124	-585.7543
		Treatment 2	-109.40000*	.67188	.000	-111.1791	-107.6209
		Control	48.73333*	.67188	.000	46.9543	50.5124
	Control	Treatment 1	-636.26667*	.67188	.000	-638.0457	-634.4876
		Treatment 2	-158.13333*	.67188	.000	-159.9124	-156.3543
		Treatment 3	-48.73333*	.67188	.000	-50.5124	-46.9543
Day_75	Treatment 1	Treatment 2	414.33333*	.85319	.000	412.0742	416.5925
		Treatment 3	503.80000*	.85319	.000	501.5408	506.0592
		Control	534.00000*	.85319	.000	531.7408	536.2592
	Treatment 2	Treatment 1	-414.33333*	.85319	.000	-416.5925	-412.0742
		Treatment 3	89.46667*	.85319	.000	87.2075	91.7258
		Control	119.66667*	.85319	.000	117.4075	121.9258
	Treatment 3	Treatment 1	-503.80000*	.85319	.000	-506.0592	-501.5408
		Treatment 2	-89.46667*	.85319	.000	-91.7258	-87.2075
		Control	30.20000*	.85319	.000	27.9408	32.4592
	Control	Treatment 1	-534.00000*	.85319	.000	-536.2592	-531.7408
		Treatment 2	-119.66667*	.85319	.000	-121.9258	-117.4075
		Treatment 3	-30.20000*	.85319	.000	-32.4592	-27.9408
Day_90	Treatment 1	Treatment 2	398.53333*	.80888	.000	396.3915	400.6752
		Treatment 3	467.33333*	.80888	.000	465.1915	469.4752
		Control	483.13333*	.80888	.000	480.9915	485.2752
	Treatment 2	Treatment 1	-398.53333*	.80888	.000	-400.6752	-396.3915
		Treatment 3	68.80000*	.80888	.000	66.6582	70.9418
		Control	84.60000*	.80888	.000	82.4582	86.7418
	Treatment 3	Treatment 1	-467.33333*	.80888	.000	-469.4752	-465.1915
		Treatment 2	-68.80000*	.80888	.000	-70.9418	-66.6582
		Control	15.80000*	.80888	.000	13.6582	17.9418
	Control	Treatment 1	-483.13333*	.80888	.000	-485.2752	-480.9915
		Treatment 2	-84.60000*	.80888	.000	-86.7418	-82.4582
		Treatment 3	-15.80000*	.80888	.000	-17.9418	-13.6582

*. The mean difference is significant at the .05 level.

ค่า TKN น้ำ

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Day_0	Between Groups	119.785	3	39.928	841.746	.000
	Within Groups	2.656	56	.047		
	Total	122.441	59			
Day_15	Between Groups	74.553	3	24.851	396.222	.000
	Within Groups	3.512	56	.063		
	Total	78.065	59			
Day_30	Between Groups	27.316	3	9.105	393.827	.000
	Within Groups	1.295	56	.023		
	Total	28.611	59			
Day_45	Between Groups	1.729	3	.576	114.333	.000
	Within Groups	.282	56	.005		
	Total	2.011	59			
Day_60	Between Groups	.000	3	.000	.	.
	Within Groups	.000	56	.000		
	Total	.000	59			
Day_75	Between Groups	.000	3	.000	.	.
	Within Groups	.000	56	.000		
	Total	.000	59			
Day_90	Between Groups	.000	3	.000	.	.
	Within Groups	.000	56	.000		
	Total	.000	59			

Post Hoc Tests

Multiple Comparisons

Tukey HSD

Dependent Variable (I)	Treatment (J)	Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Day_0	Treatment 1	Treatment 2	2.05400*	.07953	.000	1.8434	2.2646
		Treatment 3	3.25000*	.07953	.000	3.0394	3.4606
		Control	3.62333*	.07953	.000	3.4128	3.8339
	Treatment 2	Treatment 1	-2.05400*	.07953	.000	-2.2646	-1.8434
		Treatment 3	1.19600*	.07953	.000	.9854	1.4066
		Control	1.56933*	.07953	.000	1.3588	1.7799
	Treatment 3	Treatment 1	-3.25000*	.07953	.000	-3.4606	-3.0394
		Treatment 2	-1.19600*	.07953	.000	-1.4066	-.9854
		Control	.37333*	.07953	.000	.1628	.5839
	Control	Treatment 1	-3.62333*	.07953	.000	-3.8339	-3.4128
		Treatment 2	-1.56933*	.07953	.000	-1.7799	-1.3588
		Treatment 3	-.37333*	.07953	.000	-.5839	-.1628
Day_15	Treatment 1	Treatment 2	2.24000*	.09145	.000	1.9979	2.4821
		Treatment 3	2.65067*	.09145	.000	2.4085	2.8928
		Control	2.72533*	.09145	.000	2.4832	2.9675
	Treatment 2	Treatment 1	-2.24000*	.09145	.000	-2.4821	-1.9979
		Treatment 3	.41067*	.09145	.000	.1685	.6528
		Control	.48533*	.09145	.000	.2432	.7275
	Treatment 3	Treatment 1	-2.65067*	.09145	.000	-2.8928	-2.4085
		Treatment 2	-.41067*	.09145	.000	-.6528	-.1685
		Control	.07467	.09145	.846	-.1675	.3168
	Control	Treatment 1	-2.72533*	.09145	.000	-2.9675	-2.4832
		Treatment 2	-.48533*	.09145	.000	-.7275	-.2432
		Treatment 3	-.07467	.09145	.846	-.3168	.1675
Day_30	Treatment 1	Treatment 2	1.52000*	.05552	.000	1.3730	1.6670
		Treatment 3	1.57600*	.05552	.000	1.4290	1.7230
		Control	1.57600*	.05552	.000	1.4290	1.7230
	Treatment 2	Treatment 1	-1.52000*	.05552	.000	-1.6670	-1.3730
		Treatment 3	.05600	.05552	.745	-.0910	.2030
		Control	.05600	.05552	.745	-.0910	.2030
	Treatment 3	Treatment 1	-1.57600*	.05552	.000	-1.7230	-1.4290
		Treatment 2	-.05600	.05552	.745	-.2030	.0910
		Control	.00000	.05552	1.000	-.1470	.1470
	Control	Treatment 1	-1.57600*	.05552	.000	-1.7230	-1.4290
		Treatment 2	-.05600	.05552	.745	-.2030	.0910
		Treatment 3	.00000	.05552	1.000	-.1470	.1470
Day_45	Treatment 1	Treatment 2	.39200*	.02592	.000	.3234	.4606
		Treatment 3	.39200*	.02592	.000	.3234	.4606
		Control	.39200*	.02592	.000	.3234	.4606
	Treatment 2	Treatment 1	-.39200*	.02592	.000	-.4606	-.3234
		Treatment 3	.00000	.02592	1.000	-.0686	.0686
		Control	.00000	.02592	1.000	-.0686	.0686
	Treatment 3	Treatment 1	-.39200*	.02592	.000	-.4606	-.3234
		Treatment 2	.00000	.02592	1.000	-.0686	.0686
		Control	.00000	.02592	1.000	-.0686	.0686
	Control	Treatment 1	-.39200*	.02592	.000	-.4606	-.3234
		Treatment 2	.00000	.02592	1.000	-.0686	.0686
		Treatment 3	.00000	.02592	1.000	-.0686	.0686

*. The mean difference is significant at the .05 level.

ค่า P ้น้า

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Day_0	Between Groups	.303	3	.101	39.950	.000
	Within Groups	.141	56	.003		
	Total	.444	59			
Day_15	Between Groups	.000	3	.000	.	.
	Within Groups	.000	56	.000		
	Total	.000	59			
Day_30	Between Groups	.000	3	.000	.	.
	Within Groups	.000	56	.000		
	Total	.000	59			
Day_45	Between Groups	.000	3	.000	.	.
	Within Groups	.000	56	.000		
	Total	.000	59			
Day_60	Between Groups	.000	3	.000	.	.
	Within Groups	.000	56	.000		
	Total	.000	59			
Day_75	Between Groups	.000	3	.000	.	.
	Within Groups	.000	56	.000		
	Total	.000	59			
Day_90	Between Groups	.000	3	.000	.	.
	Within Groups	.000	56	.000		
	Total	.000	59			

Post Hoc Tests

Multiple Comparisons

Tukey HSD

Dependent Variab (I)	Treatment (J)	Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Day_0	Treatment 1	Treatment 2	.15467*	.01835	.000	.1061	.2032
		Treatment 3	.15600*	.01835	.000	.1074	.2046
		Control	.17733*	.01835	.000	.1288	.2259
	Treatment 2	Treatment 1	-.15467*	.01835	.000	-.2032	-.1061
		Treatment 3	.00133	.01835	1.000	-.0472	.0499
		Control	.02267	.01835	.607	-.0259	.0712
	Treatment 3	Treatment 1	-.15600*	.01835	.000	-.2046	-.1074
		Treatment 2	-.00133	.01835	1.000	-.0499	.0472
		Control	.02133	.01835	.653	-.0272	.0699
	Control	Treatment 1	-.17733*	.01835	.000	-.2259	-.1288
		Treatment 2	-.02267	.01835	.607	-.0712	.0259
		Treatment 3	-.02133	.01835	.653	-.0699	.0272

*. The mean difference is significant at the .05 level.

ค่า K นี้

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Day_0	Between Groups	498.705	3	166.235	636.825	.000
	Within Groups	14.618	56	.261		
	Total	513.323	59			
Day_15	Between Groups	374.909	3	124.970	505.476	.000
	Within Groups	13.845	56	.247		
	Total	388.754	59			
Day_30	Between Groups	309.167	3	103.056	265.726	.000
	Within Groups	21.718	56	.388		
	Total	330.885	59			
Day_45	Between Groups	172.096	3	57.365	220.582	.000
	Within Groups	14.564	56	.260		
	Total	186.660	59			
Day_60	Between Groups	124.236	3	41.412	228.270	.000
	Within Groups	10.159	56	.181		
	Total	134.395	59			
Day_75	Between Groups	44.015	3	14.672	153.705	.000
	Within Groups	5.345	56	.095		
	Total	49.361	59			
Day_90	Between Groups	9.898	3	3.299	49.554	.000
	Within Groups	3.729	56	.067		
	Total	13.627	59			

Post Hoc Tests

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Day_0	Treatment 1	Treatment 2	.17600	.18656	.782	-.3180	.6700
		Treatment 3	1.05133*	.18656	.000	.5573	1.5453
		Control	7.00333*	.18656	.000	6.5093	7.4973
	Treatment 2	Treatment 1	-.17600	.18656	.782	-.6700	.3180
		Treatment 3	.87533*	.18656	.000	.3813	1.3693
		Control	6.82733*	.18656	.000	6.3333	7.3213
	Treatment 3	Treatment 1	-1.05133*	.18656	.000	-1.5453	-.5573
		Treatment 2	-.87533*	.18656	.000	-1.3693	-.3813
		Control	5.95200*	.18656	.000	5.4580	6.4460
	Control	Treatment 1	-7.00333*	.18656	.000	-7.4973	-6.5093
		Treatment 2	-6.82733*	.18656	.000	-7.3213	-6.3333
		Treatment 3	-5.95200*	.18656	.000	-6.4460	-5.4580
Day_15	Treatment 1	Treatment 2	.58200*	.18156	.012	.1012	1.0628
		Treatment 3	2.91333*	.18156	.000	2.4326	3.3941
		Control	6.36000*	.18156	.000	5.8792	6.8408
	Treatment 2	Treatment 1	-.58200*	.18156	.012	-1.0628	-.1012
		Treatment 3	2.33133*	.18156	.000	1.8506	2.8121
		Control	5.77800*	.18156	.000	5.2972	6.2588
	Treatment 3	Treatment 1	-2.91333*	.18156	.000	-3.3941	-2.4326
		Treatment 2	-2.33133*	.18156	.000	-2.8121	-1.8506
		Control	3.44667*	.18156	.000	2.9659	3.9274
	Control	Treatment 1	-6.36000*	.18156	.000	-6.8408	-5.8792
		Treatment 2	-5.77800*	.18156	.000	-6.2588	-5.2972
		Treatment 3	-3.44667*	.18156	.000	-3.9274	-2.9659
Day_30	Treatment 1	Treatment 2	1.06400*	.22740	.000	.4619	1.6661
		Treatment 3	4.01933*	.22740	.000	3.4172	4.6215
		Control	5.68400*	.22740	.000	5.0819	6.2861
	Treatment 2	Treatment 1	-1.06400*	.22740	.000	-1.6661	-.4619
		Treatment 3	2.95533*	.22740	.000	2.3532	3.5575
		Control	4.62000*	.22740	.000	4.0179	5.2221
	Treatment 3	Treatment 1	-4.01933*	.22740	.000	-4.6215	-3.4172
		Treatment 2	-2.95533*	.22740	.000	-3.5575	-2.3532
		Control	1.66467*	.22740	.000	1.0625	2.2668
	Control	Treatment 1	-5.68400*	.22740	.000	-6.2861	-5.0819
		Treatment 2	-4.62000*	.22740	.000	-5.2221	-4.0179
		Treatment 3	-1.66467*	.22740	.000	-2.2668	-1.0625
Day_45	Treatment 1	Treatment 2	2.69867*	.18621	.000	2.2056	3.1917
		Treatment 3	3.68533*	.18621	.000	3.1923	4.1784
		Control	4.49267*	.18621	.000	3.9996	4.9857
	Treatment 2	Treatment 1	-2.69867*	.18621	.000	-3.1917	-2.2056
		Treatment 3	.98667*	.18621	.000	.4936	1.4797
		Control	1.79400*	.18621	.000	1.3009	2.2871
	Treatment 3	Treatment 1	-3.68533*	.18621	.000	-4.1784	-3.1923
		Treatment 2	-.98667*	.18621	.000	-1.4797	-.4936
		Control	.80733*	.18621	.000	.3143	1.3004
	Control	Treatment 1	-4.49267*	.18621	.000	-4.9857	-3.9996
		Treatment 2	-1.79400*	.18621	.000	-2.2871	-1.3009
		Treatment 3	-.80733*	.18621	.000	-1.3004	-.3143

Day_60	Treatment 1	Treatment 2	3.21067*	.15553	.000	2.7988	3.6225
		Treatment 3	3.37400*	.15553	.000	2.9622	3.7858
		Control	3.37400*	.15553	.000	2.9622	3.7858
	Treatment 2	Treatment 1	-3.21067*	.15553	.000	-3.6225	-2.7988
		Treatment 3	.16333	.15553	.721	-.2485	.5752
		Control	.16333	.15553	.721	-.2485	.5752
	Treatment 3	Treatment 1	-3.37400*	.15553	.000	-3.7858	-2.9622
		Treatment 2	-.16333	.15553	.721	-.5752	.2485
		Control	.00000	.15553	1.000	-.4118	.4118
	Control	Treatment 1	-3.37400*	.15553	.000	-3.7858	-2.9622
		Treatment 2	-.16333	.15553	.721	-.5752	.2485
		Treatment 3	.00000	.15553	1.000	-.4118	.4118
Day_75	Treatment 1	Treatment 2	1.97800*	.11282	.000	1.6793	2.2767
		Treatment 3	1.97800*	.11282	.000	1.6793	2.2767
		Control	1.97800*	.11282	.000	1.6793	2.2767
	Treatment 2	Treatment 1	-1.97800*	.11282	.000	-2.2767	-1.6793
		Treatment 3	.00000	.11282	1.000	-.2987	.2987
		Control	.00000	.11282	1.000	-.2987	.2987
	Treatment 3	Treatment 1	-1.97800*	.11282	.000	-2.2767	-1.6793
		Treatment 2	.00000	.11282	1.000	-.2987	.2987
		Control	.00000	.11282	1.000	-.2987	.2987
	Control	Treatment 1	-1.97800*	.11282	.000	-2.2767	-1.6793
		Treatment 2	.00000	.11282	1.000	-.2987	.2987
		Treatment 3	.00000	.11282	1.000	-.2987	.2987
Day_90	Treatment 1	Treatment 2	.93800*	.09422	.000	.6885	1.1875
		Treatment 3	.93800*	.09422	.000	.6885	1.1875
		Control	.93800*	.09422	.000	.6885	1.1875
	Treatment 2	Treatment 1	-.93800*	.09422	.000	-1.1875	-.6885
		Treatment 3	.00000	.09422	1.000	-.2495	.2495
		Control	.00000	.09422	1.000	-.2495	.2495
	Treatment 3	Treatment 1	-.93800*	.09422	.000	-1.1875	-.6885
		Treatment 2	.00000	.09422	1.000	-.2495	.2495
		Control	.00000	.09422	1.000	-.2495	.2495
	Control	Treatment 1	-.93800*	.09422	.000	-1.1875	-.6885
		Treatment 2	.00000	.09422	1.000	-.2495	.2495
		Treatment 3	.00000	.09422	1.000	-.2495	.2495

*. The mean difference is significant at the .05 level.

ผลการวิเคราะห์ข้อมูลความสูงต้นยาง

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Day_0	Between Groups	307.944	3	102.648	2.100	.111
	Within Groups	2737.217	56	48.879		
	Total	3045.162	59			
Day_15	Between Groups	123.309	3	41.103	.775	.513
	Within Groups	2970.000	56	53.036		
	Total	3093.309	59			
Day_30	Between Groups	140.137	3	46.712	.892	.451
	Within Groups	2931.620	56	52.350		
	Total	3071.757	59			
Day_45	Between Groups	385.297	3	128.432	2.201	.098
	Within Groups	3267.780	56	58.353		
	Total	3653.077	59			
Day_60	Between Groups	464.462	3	154.821	1.919	.137
	Within Groups	4518.448	56	80.687		
	Total	4982.910	59			
Day_75	Between Groups	692.167	3	230.722	2.543	.065
	Within Groups	5079.840	56	90.711		
	Total	5772.007	59			
Day_90	Between Groups	780.986	3	260.329	2.873	.044
	Within Groups	5073.904	56	90.605		
	Total	5854.890	59			

Post Hoc Tests

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Day_0	Treatment 1	Treatment 2	-2.48667	2.55288	.765	-9.2464	4.2731
		Treatment 3	-6.08667	2.55288	.092	-12.8464	.6731
		Control	-4.40667	2.55288	.320	-11.1664	2.3531
	Treatment 2	Treatment 1	2.48667	2.55288	.765	-4.2731	9.2464
		Treatment 3	-3.60000	2.55288	.498	-10.3597	3.1597
		Control	-1.92000	2.55288	.875	-8.6797	4.8397
	Treatment 3	Treatment 1	6.08667	2.55288	.092	-.6731	12.8464
		Treatment 2	3.60000	2.55288	.498	-3.1597	10.3597
		Control	1.68000	2.55288	.912	-5.0797	8.4397
	Control	Treatment 1	4.40667	2.55288	.320	-2.3531	11.1664
		Treatment 2	1.92000	2.55288	.875	-4.8397	8.6797
		Treatment 3	-1.68000	2.55288	.912	-8.4397	5.0797
Day_15	Treatment 1	Treatment 2	-2.89333	2.65922	.698	-9.9346	4.1480
		Treatment 3	-3.90667	2.65922	.463	-10.9480	3.1346
		Control	-2.24000	2.65922	.834	-9.2813	4.8013
	Treatment 2	Treatment 1	2.89333	2.65922	.698	-4.1480	9.9346
		Treatment 3	-1.01333	2.65922	.981	-8.0546	6.0280
		Control	.65333	2.65922	.995	-6.3880	7.6946
	Treatment 3	Treatment 1	3.90667	2.65922	.463	-3.1346	10.9480
		Treatment 2	1.01333	2.65922	.981	-6.0280	8.0546
		Control	1.66667	2.65922	.923	-5.3746	8.7080
	Control	Treatment 1	2.24000	2.65922	.834	-4.8013	9.2813
		Treatment 2	-.65333	2.65922	.995	-7.6946	6.3880
		Treatment 3	-1.66667	2.65922	.923	-8.7080	5.3746
Day_30	Treatment 1	Treatment 2	-4.08000	2.64198	.418	-11.0757	2.9157
		Treatment 3	-2.22000	2.64198	.835	-9.2157	4.7757
		Control	-.94667	2.64198	.984	-7.9423	6.0490
	Treatment 2	Treatment 1	4.08000	2.64198	.418	-2.9157	11.0757
		Treatment 3	1.86000	2.64198	.895	-5.1357	8.8557
		Control	3.13333	2.64198	.638	-3.8623	10.1290
	Treatment 3	Treatment 1	2.22000	2.64198	.835	-4.7757	9.2157
		Treatment 2	-1.86000	2.64198	.895	-8.8557	5.1357
		Control	1.27333	2.64198	.963	-5.7223	8.2690
	Control	Treatment 1	.94667	2.64198	.984	-6.0490	7.9423
		Treatment 2	-3.13333	2.64198	.638	-10.1290	3.8623
		Treatment 3	-1.27333	2.64198	.963	-8.2690	5.7223
Day_45	Treatment 1	Treatment 2	-6.00000	2.78934	.150	-13.3859	1.3859
		Treatment 3	-2.76000	2.78934	.756	-10.1459	4.6259
		Control	.27333	2.78934	1.000	-7.1125	7.6592
	Treatment 2	Treatment 1	6.00000	2.78934	.150	-1.3859	13.3859
		Treatment 3	3.24000	2.78934	.653	-4.1459	10.6259
		Control	6.27333	2.78934	.123	-1.1125	13.6592
	Treatment 3	Treatment 1	2.76000	2.78934	.756	-4.6259	10.1459
		Treatment 2	-3.24000	2.78934	.653	-10.6259	4.1459
		Control	3.03333	2.78934	.699	-4.3525	10.4192
	Control	Treatment 1	-.27333	2.78934	1.000	-7.6592	7.1125
		Treatment 2	-6.27333	2.78934	.123	-13.6592	1.1125
		Treatment 3	-3.03333	2.78934	.699	-10.4192	4.3525

Day_60	Treatment 1	Treatment 2	-3.57333	3.27997	.697	-12.2583	5.1117
		Treatment 3	1.05333	3.27997	.988	-7.6317	9.7383
		Control	4.22000	3.27997	.575	-4.4650	12.9050
	Treatment 2	Treatment 1	3.57333	3.27997	.697	-5.1117	12.2583
		Treatment 3	4.62667	3.27997	.498	-4.0583	13.3117
		Control	7.79333	3.27997	.094	-.8917	16.4783
	Treatment 3	Treatment 1	-1.05333	3.27997	.988	-9.7383	7.6317
		Treatment 2	-4.62667	3.27997	.498	-13.3117	4.0583
		Control	3.16667	3.27997	.769	-5.5183	11.8517
	Control	Treatment 1	-4.22000	3.27997	.575	-12.9050	4.4650
		Treatment 2	-7.79333	3.27997	.094	-16.4783	.8917
		Treatment 3	-3.16667	3.27997	.769	-11.8517	5.5183
Day_75	Treatment 1	Treatment 2	-4.54667	3.47777	.562	-13.7554	4.6621
		Treatment 3	1.32000	3.47777	.981	-7.8887	10.5287
		Control	4.94667	3.47777	.491	-4.2621	14.1554
	Treatment 2	Treatment 1	4.54667	3.47777	.562	-4.6621	13.7554
		Treatment 3	5.86667	3.47777	.340	-3.3421	15.0754
		Control	9.49333*	3.47777	.041	.2846	18.7021
	Treatment 3	Treatment 1	-1.32000	3.47777	.981	-10.5287	7.8887
		Treatment 2	-5.86667	3.47777	.340	-15.0754	3.3421
		Control	3.62667	3.47777	.725	-5.5821	12.8354
	Control	Treatment 1	-4.94667	3.47777	.491	-14.1554	4.2621
		Treatment 2	-9.49333*	3.47777	.041	-18.7021	-.2846
		Treatment 3	-3.62667	3.47777	.725	-12.8354	5.5821
Day_90	Treatment 1	Treatment 2	-4.29333	3.47573	.607	-13.4967	4.9100
		Treatment 3	2.04667	3.47573	.935	-7.1567	11.2500
		Control	5.69333	3.47573	.366	-3.5100	14.8967
	Treatment 2	Treatment 1	4.29333	3.47573	.607	-4.9100	13.4967
		Treatment 3	6.34000	3.47573	.273	-2.8634	15.5434
		Control	9.98667*	3.47573	.028	.7833	19.1900
	Treatment 3	Treatment 1	-2.04667	3.47573	.935	-11.2500	7.1567
		Treatment 2	-6.34000	3.47573	.273	-15.5434	2.8634
		Control	3.64667	3.47573	.721	-5.5567	12.8500
	Control	Treatment 1	-5.69333	3.47573	.366	-14.8967	3.5100
		Treatment 2	-9.98667*	3.47573	.028	-19.1900	-.7833
		Treatment 3	-3.64667	3.47573	.721	-12.8500	5.5567

*. The mean difference is significant at the .05 level.

ผลการวิเคราะห์ข้อมูลขนาดเส้นผ่าศูนย์กลางของต้นยาง

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Day_0	Between Groups	.046	3	.015	1.849	.149
	Within Groups	.461	56	.008		
	Total	.507	59			
Day_15	Between Groups	.025	3	.008	1.151	.337
	Within Groups	.408	56	.007		
	Total	.433	59			
Day_30	Between Groups	.015	3	.005	.668	.575
	Within Groups	.430	56	.008		
	Total	.445	59			
Day_45	Between Groups	.028	3	.009	1.094	.359
	Within Groups	.477	56	.009		
	Total	.504	59			
Day_60	Between Groups	.063	3	.021	2.105	.110
	Within Groups	.555	56	.010		
	Total	.618	59			
Day_75	Between Groups	.102	3	.034	3.854	.014
	Within Groups	.492	56	.009		
	Total	.594	59			
Day_90	Between Groups	.104	3	.035	3.481	.022
	Within Groups	.558	56	.010		
	Total	.662	59			

Post Hoc Tests

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Day_0	Treatment 1	Treatment 2	.05067	.03313	.427	-.0371	.1384
		Treatment 3	-.02267	.03313	.903	-.1104	.0651
		Control	.02667	.03313	.852	-.0611	.1144
	Treatment 2	Treatment 1	-.05067	.03313	.427	-.1384	.0371
		Treatment 3	-.07333	.03313	.132	-.1611	.0144
		Control	-.02400	.03313	.887	-.1117	.0637
	Treatment 3	Treatment 1	.02267	.03313	.903	-.0651	.1104
		Treatment 2	.07333	.03313	.132	-.0144	.1611
		Control	.04933	.03313	.451	-.0384	.1371
	Control	Treatment 1	-.02667	.03313	.852	-.1144	.0611
		Treatment 2	.02400	.03313	.887	-.0637	.1117
		Treatment 3	-.04933	.03313	.451	-.1371	.0384
Day_15	Treatment 1	Treatment 2	.04400	.03116	.497	-.0385	.1265
		Treatment 3	.02000	.03116	.918	-.0625	.1025
		Control	.05200	.03116	.350	-.0305	.1345
	Treatment 2	Treatment 1	-.04400	.03116	.497	-.1265	.0385
		Treatment 3	-.02400	.03116	.868	-.1065	.0585
		Control	.00800	.03116	.994	-.0745	.0905
	Treatment 3	Treatment 1	-.02000	.03116	.918	-.1025	.0625
		Treatment 2	.02400	.03116	.868	-.0585	.1065
		Control	.03200	.03116	.734	-.0505	.1145
	Control	Treatment 1	-.05200	.03116	.350	-.1345	.0305
		Treatment 2	-.00800	.03116	.994	-.0905	.0745
		Treatment 3	-.03200	.03116	.734	-.1145	.0505
Day_30	Treatment 1	Treatment 2	.00333	.03199	1.000	-.0814	.0880
		Treatment 3	.00200	.03199	1.000	-.0827	.0867
		Control	.03867	.03199	.624	-.0460	.1234
	Treatment 2	Treatment 1	-.00333	.03199	1.000	-.0880	.0814
		Treatment 3	-.00133	.03199	1.000	-.0860	.0834
		Control	.03533	.03199	.688	-.0494	.1200
	Treatment 3	Treatment 1	-.00200	.03199	1.000	-.0867	.0827
		Treatment 2	.00133	.03199	1.000	-.0834	.0860
		Control	.03667	.03199	.663	-.0480	.1214
	Control	Treatment 1	-.03867	.03199	.624	-.1234	.0460
		Treatment 2	-.03533	.03199	.688	-.1200	.0494
		Treatment 3	-.03667	.03199	.663	-.1214	.0480
Day_45	Treatment 1	Treatment 2	.00333	.03368	1.000	-.0859	.0925
		Treatment 3	.01267	.03368	.982	-.0765	.1019
		Control	.05400	.03368	.385	-.0352	.1432
	Treatment 2	Treatment 1	-.00333	.03368	1.000	-.0925	.0859
		Treatment 3	.00933	.03368	.992	-.0799	.0985
		Control	.05067	.03368	.442	-.0385	.1399
	Treatment 3	Treatment 1	-.01267	.03368	.982	-.1019	.0765
		Treatment 2	-.00933	.03368	.992	-.0985	.0799
		Control	.04133	.03368	.612	-.0479	.1305
	Control	Treatment 1	-.05400	.03368	.385	-.1432	.0352
		Treatment 2	-.05067	.03368	.442	-.1399	.0385
		Treatment 3	-.04133	.03368	.612	-.1305	.0479

Day_60	Treatment 1	Treatment 2	-.01133	.03636	.989	-.1076	.0849
		Treatment 3	-.01200	.03636	.987	-.1083	.0843
		Control	.06600	.03636	.277	-.0303	.1623
	Treatment 2	Treatment 1	.01133	.03636	.989	-.0849	.1076
		Treatment 3	-.00067	.03636	1.000	-.0969	.0956
		Control	.07733	.03636	.157	-.0189	.1736
	Treatment 3	Treatment 1	.01200	.03636	.987	-.0843	.1083
		Treatment 2	.00067	.03636	1.000	-.0956	.0969
		Control	.07800	.03636	.152	-.0183	.1743
	Control	Treatment 1	-.06600	.03636	.277	-.1623	.0303
		Treatment 2	-.07733	.03636	.157	-.1736	.0189
		Treatment 3	-.07800	.03636	.152	-.1743	.0183
Day_75	Treatment 1	Treatment 2	-.01000	.03424	.991	-.1007	.0807
		Treatment 3	-.00800	.03424	.995	-.0987	.0827
		Control	.08867	.03424	.057	-.0020	.1793
	Treatment 2	Treatment 1	.01000	.03424	.991	-.0807	.1007
		Treatment 3	.00200	.03424	1.000	-.0887	.0927
		Control	.09867*	.03424	.028	.0080	.1893
	Treatment 3	Treatment 1	.00800	.03424	.995	-.0827	.0987
		Treatment 2	-.00200	.03424	1.000	-.0927	.0887
		Control	.09667*	.03424	.032	.0060	.1873
	Control	Treatment 1	-.08867	.03424	.057	-.1793	.0020
		Treatment 2	-.09867*	.03424	.028	-.1893	-.0080
		Treatment 3	-.09667*	.03424	.032	-.1873	-.0060
Day_90	Treatment 1	Treatment 2	-.02533	.03645	.899	-.1218	.0712
		Treatment 3	-.01800	.03645	.960	-.1145	.0785
		Control	.07933	.03645	.142	-.0172	.1758
	Treatment 2	Treatment 1	.02533	.03645	.899	-.0712	.1218
		Treatment 3	.00733	.03645	.997	-.0892	.1038
		Control	.10467*	.03645	.029	.0082	.2012
	Treatment 3	Treatment 1	.01800	.03645	.960	-.0785	.1145
		Treatment 2	-.00733	.03645	.997	-.1038	.0892
		Control	.09733*	.03645	.047	.0008	.1938
	Control	Treatment 1	-.07933	.03645	.142	-.1758	.0172
		Treatment 2	-.10467*	.03645	.029	-.2012	-.0082
		Treatment 3	-.09733*	.03645	.047	-.1938	-.0008

*. The mean difference is significant at the .05 level.

ผลการวิเคราะห์ข้อมูลจำนวนใบของต้นยาง

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Day_0	Between Groups	125.383	3	41.794	.876	.459
	Within Groups	2673.200	56	47.736		
	Total	2798.583	59			
Day_15	Between Groups	41.517	3	13.839	.196	.899
	Within Groups	3954.667	56	70.619		
	Total	3996.183	59			
Day_30	Between Groups	461.783	3	153.928	1.464	.234
	Within Groups	5887.867	56	105.140		
	Total	6349.650	59			
Day_45	Between Groups	545.517	3	181.839	1.606	.198
	Within Groups	6340.133	56	113.217		
	Total	6885.650	59			
Day_60	Between Groups	1257.250	3	419.083	2.946	.041
	Within Groups	7966.400	56	142.257		
	Total	9223.650	59			
Day_75	Between Groups	2242.267	3	747.422	4.335	.008
	Within Groups	9655.467	56	172.419		
	Total	11897.733	59			
Day_90	Between Groups	2497.600	3	832.533	5.022	.004
	Within Groups	9283.333	56	165.774		
	Total	11780.933	59			

Post Hoc Tests

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Day_0	Treatment 1	Treatment 2	3.800	2.523	.441	-2.88	10.48
		Treatment 3	2.067	2.523	.845	-4.61	8.75
		Control	.733	2.523	.991	-5.95	7.41
	Treatment 2	Treatment 1	-3.800	2.523	.441	-10.48	2.88
		Treatment 3	-1.733	2.523	.902	-8.41	4.95
		Control	-3.067	2.523	.620	-9.75	3.61
	Treatment 3	Treatment 1	-2.067	2.523	.845	-8.75	4.61
		Treatment 2	1.733	2.523	.902	-4.95	8.41
		Control	-1.333	2.523	.952	-8.01	5.35
	Control	Treatment 1	-.733	2.523	.991	-7.41	5.95
		Treatment 2	3.067	2.523	.620	-3.61	9.75
		Treatment 3	1.333	2.523	.952	-5.35	8.01
Day_15	Treatment 1	Treatment 2	.533	3.069	.998	-7.59	8.66
		Treatment 3	1.333	3.069	.972	-6.79	9.46
		Control	2.200	3.069	.890	-5.93	10.33
	Treatment 2	Treatment 1	-.533	3.069	.998	-8.66	7.59
		Treatment 3	.800	3.069	.994	-7.33	8.93
		Control	1.667	3.069	.948	-6.46	9.79
	Treatment 3	Treatment 1	-1.333	3.069	.972	-9.46	6.79
		Treatment 2	-.800	3.069	.994	-8.93	7.33
		Control	.867	3.069	.992	-7.26	8.99
	Control	Treatment 1	-2.200	3.069	.890	-10.33	5.93
		Treatment 2	-1.667	3.069	.948	-9.79	6.46
		Treatment 3	-.867	3.069	.992	-8.99	7.26
Day_30	Treatment 1	Treatment 2	-5.467	3.744	.468	-15.38	4.45
		Treatment 3	-3.667	3.744	.762	-13.58	6.25
		Control	1.467	3.744	.979	-8.45	11.38
	Treatment 2	Treatment 1	5.467	3.744	.468	-4.45	15.38
		Treatment 3	1.800	3.744	.963	-8.11	11.71
		Control	6.933	3.744	.261	-2.98	16.85
	Treatment 3	Treatment 1	3.667	3.744	.762	-6.25	13.58
		Treatment 2	-1.800	3.744	.963	-11.71	8.11
		Control	5.133	3.744	.523	-4.78	15.05
	Control	Treatment 1	-1.467	3.744	.979	-11.38	8.45
		Treatment 2	-6.933	3.744	.261	-16.85	2.98
		Treatment 3	-5.133	3.744	.523	-15.05	4.78
Day_45	Treatment 1	Treatment 2	-4.000	3.885	.733	-14.29	6.29
		Treatment 3	-2.733	3.885	.895	-13.02	7.55
		Control	3.867	3.885	.753	-6.42	14.15
	Treatment 2	Treatment 1	4.000	3.885	.733	-6.29	14.29
		Treatment 3	1.267	3.885	.988	-9.02	11.55
		Control	7.867	3.885	.191	-2.42	18.15
	Treatment 3	Treatment 1	2.733	3.885	.895	-7.55	13.02
		Treatment 2	-1.267	3.885	.988	-11.55	9.02
		Control	6.600	3.885	.334	-3.69	16.89
	Control	Treatment 1	-3.867	3.885	.753	-14.15	6.42
		Treatment 2	-7.867	3.885	.191	-18.15	2.42
		Treatment 3	-6.600	3.885	.334	-16.89	3.69

Day_60	Treatment 1	Treatment 2	-2.400	4.355	.946	-13.93	9.13
		Treatment 3	1.867	4.355	.973	-9.67	13.40
		Control	9.800	4.355	.122	-1.73	21.33
	Treatment 2	Treatment 1	2.400	4.355	.946	-9.13	13.93
		Treatment 3	4.267	4.355	.762	-7.27	15.80
		Control	12.200*	4.355	.034	.67	23.73
	Treatment 3	Treatment 1	-1.867	4.355	.973	-13.40	9.67
		Treatment 2	-4.267	4.355	.762	-15.80	7.27
		Control	7.933	4.355	.274	-3.60	19.47
	Control	Treatment 1	-9.800	4.355	.122	-21.33	1.73
		Treatment 2	-12.200*	4.355	.034	-23.73	-.67
		Treatment 3	-7.933	4.355	.274	-19.47	3.60
Day_75	Treatment 1	Treatment 2	-3.933	4.795	.845	-16.63	8.76
		Treatment 3	2.267	4.795	.965	-10.43	14.96
		Control	12.600	4.795	.052	-.10	25.30
	Treatment 2	Treatment 1	3.933	4.795	.845	-8.76	16.63
		Treatment 3	6.200	4.795	.571	-6.50	18.90
		Control	16.533*	4.795	.006	3.84	29.23
	Treatment 3	Treatment 1	-2.267	4.795	.965	-14.96	10.43
		Treatment 2	-6.200	4.795	.571	-18.90	6.50
		Control	10.333	4.795	.149	-2.36	23.03
	Control	Treatment 1	-12.600	4.795	.052	-25.30	.10
		Treatment 2	-16.533*	4.795	.006	-29.23	-3.84
		Treatment 3	-10.333	4.795	.149	-23.03	2.36
Day_90	Treatment 1	Treatment 2	-3.600	4.701	.869	-16.05	8.85
		Treatment 3	1.733	4.701	.983	-10.72	14.18
		Control	13.600*	4.701	.027	1.15	26.05
	Treatment 2	Treatment 1	3.600	4.701	.869	-8.85	16.05
		Treatment 3	5.333	4.701	.670	-7.12	17.78
		Control	17.200*	4.701	.003	4.75	29.65
	Treatment 3	Treatment 1	-1.733	4.701	.983	-14.18	10.72
		Treatment 2	-5.333	4.701	.670	-17.78	7.12
		Control	11.867	4.701	.067	-.58	24.32
	Control	Treatment 1	-13.600*	4.701	.027	-26.05	-1.15
		Treatment 2	-17.200*	4.701	.003	-29.65	-4.75
		Treatment 3	-11.867	4.701	.067	-24.32	.58

*. The mean difference is significant at the .05 level.

APPENDIX B

THE 7th KU – KPS CONFERENCE 7 – 8 DECEMBER 2010

ผลของการใช้ปุ๋ยผสมกากจี้แป็งจากกระบวนการผลิตน้ำยางข้นและมูลสุกรต่อการเจริญเติบโตของ
กล้วยาง

**THE EFFECTS OF THE BLENDED FERTILIZER OF THE CENTRIFUGED
RESIDUE OF RUBBER LATEX AND SWINE MANURE FOR THE GROWTH
ENHANCEMENT OF RUBBER PLANTS**

ธัญญา อุตราภรณ์¹, รุ่งจรัส หุตะเจริญ¹, ชาลี นาวานุเคราะห์²

Thanya Uttraporn¹, Rungjarat Hutajareon¹, Charlie Navanugraha²

บทคัดย่อ

งานวิจัยชิ้นนี้ได้ศึกษาการใช้ประโยชน์จากปุ๋ยผสมกากจี้แป็ง และมูลสุกร จำนวน 4 สูตร คือ สูตรที่ 1 ปุ๋ยเคมีสูตร 20-8-20 สูตรที่ 2 กากจี้แป็งผสมมูลสุกรอัตราส่วน 1:1 โดยน้ำหนัก และปรับค่า N-P-K ด้วยปุ๋ยเคมีจนเทียบเท่าธาตุอาหารสูตร 20-8-20 สูตรที่ 3 กากจี้แป็งผสมมูลสุกรอัตราส่วน 1:1 โดยน้ำหนัก และสูตรที่ 4 ชุดควบคุม วางแผนการทดลองแบบ Completely Randomized Design (CRD)

ผลการทดลองพบว่า การใช้ปุ๋ยผสมสูตรที่ 2 มีผลให้ความสูงต้น ขนาดเส้นรอบวงลำต้น และจำนวนใบของกล้วยางพารามากที่สุด ไม่แตกต่างกับการใช้ปุ๋ยสูตรที่ 3 หรือ 1 ขณะที่สูตรควบคุม มีผลให้การเจริญเติบโตของกล้วยางพาราน้อยที่สุด

คำสำคัญ: กากจี้แป็ง มูลสุกร ปุ๋ยผสม ยางพารา

¹สาขาวิชาเทคโนโลยีที่เหมาะสมเพื่อการพัฒนาทรัพยากรธรรมชาติและสิ่งแวดล้อม คณะสิ่งแวดล้อมและทรัพยากรศาสตร์ มหาวิทยาลัยมหิดล วิทยาเขตศาลายา จ.นครปฐม 73170

Department of Appropriate Technology for Resources and Environmental Development, Faculty of Environment and Resource studies, Mahidol University Salaya Campus, Nakhon Pathom 73170

² สาขาวิชาสิ่งแวดล้อมศึกษา คณะสิ่งแวดล้อมและทรัพยากรศาสตร์ มหาวิทยาลัยมหาสารคาม จ.มหาสารคาม 44150

Department of Environmental Studies, Faculty of Environment and Resource studies, Mahasarakham University, Maha Sarakham 44150

ABSTRACT

This research aimed to study the benefits of the blended fertilizer of centrifuged residue of rubber latex and swine manure, altogether 4 formulae: formula 1, chemical fertilizer with 20-8-20; formula 2, centrifuged residue and swine manure in proportion of 1:1 by weight was adjusted by N-P-K elements with chemical substance for the concentration of 20-8-20; formula 3, centrifuged residue and swine manure were mixed in the proportion of 1:1 by weight; and formula 4, controlled set, the experiment was planned in Completely Randomized Design (CRD).

This study found that there was no different in using formula 2, 3 or 1 in terms of height, girth and number of leaves of rubber tree sprouts; However, growth of rubber tree sprouts was slightly less for the controlled set (formula 4).

Keywords : rubber latex residue, swine manure, blended fertilizer, para rubber (*Hevea brasiliensis*)

E-mail : m_memost@hotmail.com

บทนำ

ยางพาราเป็นพืชเศรษฐกิจที่สำคัญของประเทศไทยอีกทั้งยังเป็นผู้ส่งออกรายใหญ่ที่สุดของโลกซึ่งมีอัตราการส่งออกเพิ่มขึ้นจาก 1.84 ล้านตัน ในปี พ.ศ.2540 เป็น 2.71 ล้านตัน ในปี พ.ศ.2551 โดยราคาของยางพารามีแนวโน้มสูงขึ้นทุกปี จึงทำให้เกษตรกรหันมาสนใจปลูกยางพารามากขึ้น ส่งผลให้ในประเทศไทย มีพื้นที่ปลูกยางพารากระจายเกือบทั่วประเทศรวม 16.89 ล้านไร่ ในปี พ.ศ. 2551 ซึ่งมีพื้นที่เพิ่มขึ้นมาจากเดิม 14.34 ล้านไร่ ในปี 2549 โดยพื้นที่ที่ปลูกส่วนใหญ่อยู่ในภาคใต้ คือ 11.34 ล้านไร่ โดยเฉพาะจังหวัดสุราษฎร์ธานีมีการปลูกมากที่สุดคือ 1.87 ล้านไร่ รองลงมาคือ ภาคตะวันออกเฉียงเหนือ 2.84 ล้านไร่ ภาคตะวันออกรวมภาคกลาง 2.10 ล้านไร่ และภาคเหนือ 0.60 ล้านไร่(สถาบันวิจัยยาง กรมวิชาการเกษตร, 2553) ด้วยเหตุนี้ ทำให้มีปริมาณการนำเข้าปุ๋ยเคมีจาก 3.73 ล้านตันในปี พ.ศ.2547 เพิ่มขึ้นเป็น 3.87 ล้านตันในปี พ.ศ.2552 (ฝ่ายปุ๋ยเคมี สำนักควบคุมพืชและวัสดุการเกษตร, 2552) ทำให้ส่งผลกระทบต่อต้นทุนการผลิตและรายได้ของเกษตรกรโดยตรง จากปัญหาดังกล่าวจึงเห็นว่าหากมีการนำวัสดุเหลือทิ้งมาใช้แทนปุ๋ยเคมี จะสามารถช่วยลดปัญหาเหล่านี้ลงได้

อุปกรณ์และวิธีการ

1. ศึกษาลักษณะทางกายภาพและเคมีของกากขี้เป้ง

ดำเนินการ โดยเก็บตัวอย่างกากขี้เป้ง จากโรงงานอุตสาหกรรมน้ำยางข้น ในจังหวัดสุราษฎร์ธานี จากนั้นนำตัวอย่างมาวิเคราะห์ลักษณะทางกายภาพและเคมี ตามวิธีของกองวิเคราะห์ดิน กรมพัฒนา

ที่ดิน (กองวิเคราะห์ดิน, 2544) ได้แก่ ค่าความเป็นกรด-ด่าง ค่าการนำไฟฟ้า ปริมาณอินทรีย์วัตถุ ในโตรเจนทั้งหมด ฟอสฟอรัสที่เป็นประโยชน์ โพแทสเซียมที่แลกเปลี่ยนได้ ค่าความจุแลกเปลี่ยนแคตไอออน และอัตราย่อยละความอิ่มตัวด้วยประจุบวกต่าง

2. ศึกษาลักษณะทางกายภาพและเคมีของมูลสุกร

ดำเนินการเก็บรวบรวมมูลสุกรมาจากฟาร์มสุกรที่ไม่มีการใช้โซดาไฟเพื่อกำจัดกลิ่นและไล่แมลง จากนั้น นำตัวอย่างมาวิเคราะห์ โดยใช้วิธีเดียวกันกับการศึกษาลักษณะทางกายภาพและเคมีของกากจี้เป้่ง

3. ศึกษาการใช้ประโยชน์จากปุ๋ยผสมกากจี้เป้่งและมูลสุกร

การวิจัยครั้งนี้ได้ศึกษาการใช้ประโยชน์จากปุ๋ยผสมกากจี้เป้่งและมูลสุกร ซึ่งได้ผสมปุ๋ยขึ้นมา 4 สูตร คือสูตรที่ 1 ปุ๋ยเคมีสูตร 20-8-20 สูตรที่ 2 กากจี้เป้่งผสมมูลสุกร อัตราส่วน 1:1 โดยน้ำหนัก และปรับค่า N-P-K ด้วยปุ๋ยเคมีจนเทียบเท่าธาตุอาหารสูตร 20-8-20 สูตรที่ 3 กากจี้เป้่งผสมมูลสุกร อัตราส่วน 1:1 โดยน้ำหนัก และสูตรที่ 4 ดำรับควบคุม (ดินเดิมไม่เติมสิ่งทดลอง) วางแผนการทดลองแบบ สุ่มตลอด (Completely Randomized Design, CRD) จำนวน 15 ซ้ำ ทดสอบกับต้นกล้ายางชำถุง สำเร็จรูปพันธุ์ RRIM 600 อายุ 2 เดือน เดิมปุ๋ยผสม 5 กรัม/ถุง (นุชนารถ, 2550; กรมวิชาการเกษตร, 2547) มีการติดตามวัดผลการเจริญเติบโตของต้นกล้ายางทุก 15 วัน เป็นเวลา 90 วัน ได้แก่ ความสูงต้น ขนาดเส้นรอบวงลำต้น และจำนวนใบ ที่ระดับ 3 ซม. จากจุดแตกตาข้างพารา จากนั้น ศึกษาลักษณะทางเคมีของดินภายหลังการทดลองตามวิธีของกองวิเคราะห์ดิน กรมพัฒนาที่ดิน (กองวิเคราะห์ดิน, 2544) ได้แก่ ค่าความเป็นกรด-ด่าง ค่าการนำไฟฟ้า ปริมาณอินทรีย์วัตถุ ในโตรเจนทั้งหมด ฟอสฟอรัสที่เป็นประโยชน์ โพแทสเซียมที่แลกเปลี่ยนได้ ค่าความจุแลกเปลี่ยนแคตไอออน และอัตราย่อยละความอิ่มตัวด้วยประจุบวกต่าง ข้อมูลที่ได้ทำการวิเคราะห์ด้วยวิธีการวิเคราะห์ความแปรปรวน (analysis of variance: ANOVA) เพื่อวิเคราะห์ความแตกต่างทางสถิติในระหว่างกลุ่มทดลองที่ได้รับปุ๋ยสูตรผสมที่แตกต่างกันเพื่อเปรียบเทียบประสิทธิภาพของปุ๋ยผสมแต่ละชนิด ถ้าแตกต่างกันจะทำการเปรียบเทียบความแตกต่างโดยวิธี Tukey's HSD ของตัวแปรนั้น

ผลการทดลองและวิจารณ์

1. ลักษณะทางกายภาพและเคมีของกากจี้เป้่ง

จากการศึกษาลักษณะทางกายภาพของกากจี้เป้่ง พบว่า มีกลิ่นเหม็น มีสีขาวหรือสีเหลืองอ่อน จัดเป็นของเสียที่มีลักษณะแข็ง ภายในประกอบด้วยสิ่งเจือปนต่างๆ เช่น ฟัน เปลือกไม้ เศษใบไม้ ส่วนสมบัติทางเคมีของกากจี้เป้่ง พบว่า มีปริมาณธาตุอาหารที่สำคัญ ได้แก่ ปริมาณในโตรเจนทั้งหมด

(9.73 % โดยน้ำหนักแห้ง) อยู่ในระดับสูงมาก ฟอสฟอรัสที่เป็นประโยชน์ (3.62 % โดยน้ำหนักแห้ง) อยู่ในระดับสูงมาก โปแตสเซียมที่แลกเปลี่ยนได้ (0.02 %) อยู่ในระดับสูงมาก ค่าความเป็นกรด-ด่าง (7.71) อยู่ในสภาพเป็นด่างเล็กน้อย ค่าการนำไฟฟ้า (1.224 dS/m) อยู่ในระดับที่ไม่เป็นอันตรายต่อพืช ปริมาณอินทรีย์วัตถุ (12.56 % โดยน้ำหนักแห้ง) อยู่ในระดับสูงมาก ค่าความจุแลกเปลี่ยนแคตไอออน (13.40 cmol/kg) อยู่ในระดับปานกลาง และอัตราร้อยละความอิ่มตัวด้วยประจุบวกด่าง (189.50 % โดยน้ำหนักแห้ง) อยู่ในระดับสูงมาก

2. ลักษณะทางกายภาพและเคมีของมูลสุกร

จากการศึกษาลักษณะทางกายภาพของมูลสุกร พบว่า มีลักษณะเป็นก้อนยุ่ย มีกลิ่นเหม็น ประกอบด้วยกากอาหารที่ย่อยไม่ได้ เช่น ส่วนที่เป็นของแข็ง เยื่อใย หรือส่วนที่ย่อยได้แต่ดูดซึมไม่ได้ และสิ่งที่ปล่อยออกมาจากร่างกายสัตว์โดยเฉพาะจากทางเดินอาหาร เช่น เยื่อบุผนังลำไส้ เยื่อเมือก แร่ธาตุแบคทีเรีย และผลผลิตของแบคทีเรีย (ธงชัย, 2546) ส่วนสมบัติทางเคมี พบว่า มีปริมาณธาตุอาหารที่สำคัญได้แก่ ปริมาณไนโตรเจนทั้งหมด (3.30 % โดยน้ำหนักแห้ง) อยู่ในระดับสูงมาก ฟอสฟอรัสที่เป็นประโยชน์ (2.32 % โดยน้ำหนักแห้ง) อยู่ในระดับสูงมาก โปแตสเซียมที่แลกเปลี่ยนได้ (1.55 % โดยน้ำหนักแห้ง) อยู่ในระดับสูงมาก ค่าความเป็นกรด-ด่าง (7.61) มีสภาพเป็นด่างเล็กน้อย ค่าการนำไฟฟ้า (6.85 dS/m) อยู่ในระดับกึ่งปานกลาง ปริมาณอินทรีย์วัตถุ (35.32 % โดยน้ำหนักแห้ง) อยู่ในระดับสูงมาก ค่าความจุแลกเปลี่ยนแคตไอออน (27.40 cmol/kg) อยู่ในระดับสูง และอัตราร้อยละความอิ่มตัวด้วยประจุบวกด่าง (398.90 %) อยู่ในระดับสูง

3. ผลของปุ๋ยผสมกากขี้แ่งและมูลสุกร ต่อการเจริญเติบโตของกล้วยพารา

3.1 ความสูงต้น

การใช้ปุ๋ยผสมกากขี้แ่ง และมูลสุกรสูตรต่างๆ มีผลให้ความสูงต้นกล้วยพาราที่อายุ 75 และ 90 วัน แตกต่างกันทางสถิติ ที่ระดับความเชื่อมั่น 0.05 (Table 1) กล่าวคือ การใช้ปุ๋ยผสม สูตรที่ 2 มีผลให้ความสูงต้นของกล้วยพารามากที่สุด ไม่แตกต่างกับการใช้ปุ๋ยผสมสูตรที่ 1 และสูตรที่ 3 ตามลำดับ ขณะที่ได้รับควบคุม มีผลให้ความสูงต้นของกล้วยพาราน้อยที่สุด

Table 1 Average height of rubber tree (cm.)

Formula	Day 0	Day15	Day30	Day45	Day60	Day75	Day90
1	34.57±6.15a ^{1/}	37.25±6.56a ^{1/}	39.15±6.40a ^{1/}	40.71±6.67a ^{1/}	44.89±10.31a ^{1/}	45.89±10.46ab ^{1/}	46.86±10.26ab ^{1/}
2	37.05±4.40a	40.15±5.54a	43.23±4.95a	46.71±6.74a	48.47±8.35a	50.43±10.43b	51.15±10.49b
3	40.65±6.79a	41.16±6.67a	42.74±6.65a	43.47±6.48a	43.84±6.44a	44.57±5.93ab	44.81±5.88ab
4	38.97±9.60a	39.49±9.69a	40.10±9.99a	40.44±10.07a	40.67±10.26a	40.94±10.56a	41.17±10.60a
F-test	ns	ns	ns	ns	ns	*	*

Mean ± SD (n=15), 1/ = The English alphabet in horizon presented that mean was significantly indifferent at level 0.05 according to Tukey's HSD method. The English alphabet in vertical presented that mean was significantly different according to Tukey's HSD method. Moreover, the line having English alphabet more than 2 in horizon; for instance ab meant mean was significant different from a and b, at level 0.05 according to Tukey's HSD method.* = significantly at level 0.05. ns = no significantly. Formula 1 is chemical fertilizer 20-8-20 and formula 2 is centrifuged residue 1:1 and it was adjusted by chemical fertilizer until get the concentration 20-8-20. Formula 3 centrifuged residue mixed swine

3.2 ขนาดเส้นรอบวงลำต้น

การใช้ปุ๋ยผสมกากขี้เป้งและมูลสุกรสูตรต่างๆ มีผลให้ขนาดเส้นรอบวงลำต้นของกล้ายางพาราที่อายุ 75 และ 90 วัน แตกต่างกันทางสถิติ ที่ระดับความเชื่อมั่น 0.05 (Table 2) กล่าวคือ การใช้ปุ๋ยผสมสูตรที่ 2 มีผลให้ขนาดเส้นรอบวงลำต้นของกล้ายางพารามากที่สุด ไม่แตกต่างกับการใช้ปุ๋ยผสมสูตรที่ 3 และสูตรที่ 1 ตามลำดับ ขณะที่ดำรับควบคุม มีผลให้ขนาดเส้นรอบวงลำต้นของกล้ายางพาราน้อยที่สุด

Table 2 Average trunk diameter (mm.)

Formula	Day 0	Day15	Day30	Day45	Day60	Day75	Day90
1	0.60±0.11a ^{1/}	0.67±0.09a ^{1/}	0.67±0.10a ^{1/}	0.70±0.11a ^{1/}	0.73±0.11a ^{1/}	0.77±0.10ab ^{1/}	0.78±0.10ab ^{1/}
2	0.55±0.05a	0.63±0.06a	0.67±0.06a	0.70±0.07a	0.74±0.09a	0.78±0.08b	0.81±0.08b
3	0.63±0.08a	0.65±0.07a	0.67±0.08a	0.69±0.08a	0.74±0.09a	0.78±0.09b	0.80±0.08b
4	0.58±0.10a	0.62±0.11a	0.63±0.10a	0.65±0.10a	0.67±0.11a	0.68±0.11a	0.70±0.13a
F-test	ns	ns	ns	ns	ns	*	*

Mean ± SD (n=15), 1/ = The English alphabet in horizon presented that mean was significantly indifferent at level 0.05 according to Tukey's HSD method. The English alphabet in vertical presented that mean was significantly different according to Tukey's HSD method. Moreover, the line having English alphabet more than 2 in horizon; for instance ab meant mean was significant different from a and b, at level 0.05 according to Tukey's HSD method. * = significantly at level 0.05. ns = no significantly. Formula 1 is chemical fertilizer 20-8-20 and formula 2 is centrifuged residue 1:1 and it was adjusted by chemical fertilizer until get the concentration 20-8-20. Formula 3 centrifuged residue mixed swine

3.3 จำนวนใบ

การใช้ปุ๋ยผสมกากจี้แป้งและมูลสุกรสูตรต่างๆ มีผลให้จำนวนใบของกล้ายางพารา ที่อายุ 60, 75 และ 90 วัน แตกต่างกันทางสถิติ ที่ระดับความเชื่อมั่น 0.05 (Table 3) กล่าวคือ การใช้ปุ๋ยผสมสูตรที่ 2 มีผลให้จำนวนใบของกล้ายางพารามากที่สุด ไม่แตกต่างกับการใช้ปุ๋ยผสมสูตรที่ 1 และ สูตรที่ 3 ตามลำดับ ขณะที่ค่ารับควบคุม มีผลให้จำนวนใบของกล้ายางพาราน้อยที่สุด

Table 3 Average leaf number

Formul a	Day 0	Day15	Day30	Day45	Day60	Day75	Day90
1	44.07±5.46a ^{1/}	41.80±7.41a ^{1/}	41.73±8.66a ^{1/}	42.93±8.82a ^{1/}	46.47±13.42ab ^{1/}	48.67±14.38ab ^{1/}	47.80±14.37b ^{1/}
2	40.27±6.55a	41.27±10.37a	47.20±11.31a	46.93±11.31a	48.87±12.77b	52.60±17.30b	51.40±16.48b
3	42.00±8.59a	40.47±8.37a	45.40±12.12a	45.67±13.17a	44.60±12.04ab	46.40±11.39ab	46.07±11.41ab
4	43.33±6.67a	39.60±7.08a	40.27±8.79a	39.07±8.59a	36.67±9.00a	36.67±7.95a	32.07±7.65a
F-test	ns	ns	ns	ns	*	*	*

Mean ± SD (n=15), 1/ = The English alphabet in horizon presented that mean was significantly indifferent at level 0.05 according to Tukey's HSD method. The English alphabet in vertical presented that mean was significantly different according to Tukey's HSD method. Moreover, the line having English alphabet more than 2 in horizon; for instance ab meant mean was significant different from a and b, at level 0.05 according to Tukey's HSD method. * = significantly at level 0.05. ns = no significantly. Formula 1 is chemical fertilizer 20-8-20 and formula 2 is centrifuged residue 1:1 and it was adjusted by chemical fertilizer until get the concentration 20-8-20. Formula 3 centrifuged residue mixed swine

สรุปผลการทดลอง

จากการศึกษาผลของปุ๋ยผสมกากจี้แป้งและมูลสุกรสูตรต่างๆ ต่อการเจริญเติบโตของกล้ายางพารา สามารถสรุปผลการทดลองได้ดังนี้

การใช้ปุ๋ยผสมสูตรที่ 2 มีผลให้ความสูงต้น ขนาดเส้นรอบวงลำต้น และจำนวนใบของกล้ายางพารามากที่สุด ไม่แตกต่างกับการใช้ปุ๋ยผสมสูตรที่ 3 หรือ สูตรที่ 1 ขณะที่ค่ารับควบคุม มีผลให้การเจริญเติบโตของกล้ายางพาราน้อยที่สุด

เอกสารอ้างอิง

กองวิเคราะห์ดิน. 2544. **วิธีวิเคราะห์ดินทางเคมี**. เอกสารทางวิชาการกองวิเคราะห์ดิน ฉบับที่1/2544 กรมพัฒนาที่ดิน กระทรวงเกษตรและสหกรณ์, กรุงเทพฯ. 129 หน้า.
กรมวิชาการเกษตร. 2547. **การผลิตต้นยางชำถุงคุณภาพมาตรฐาน**. กรมวิชาการเกษตร กระทรวงเกษตรและ สหกรณ์.

- ธงชัย มาลา. 2546. **ปุ๋ยอินทรีย์และปุ๋ยชีวภาพ : เทคนิคการผลิตและการใช้ประโยชน์**. สำนักพิมพ์มหาวิทยาลัยเกษตรศาสตร์, กรุงเทพฯ. 450 หน้า.
- นุชนารถ กังพิศดาร. **การใช้ปุ๋ยอย่างพาราอย่างมีประสิทธิภาพ**. เอกสารประกอบการฝึกอบรมพนักงานใหม่ สำนักงานกองทุนสงเคราะห์สวนยาง 27 - 29 สิงหาคม 2550 ณ มาริไทม์ ปาร์ค แอนด์สไปร์ตส์ท จ.กระบี่. สถาบันวิจัยยาง กรมวิชาการเกษตร, กรุงเทพฯ.
- ฝ่ายปุ๋ยเคมี สำนักควบคุมพืชและวัสดุการเกษตร กรมวิชาการเกษตร สำนักงานเศรษฐกิจการเกษตร กระทรวงเกษตรและสหกรณ์. http://www.oae.go.th/ewt_news.php?nid=151##M. เข้าถึงข้อมูลวันที่ 5 ตุลาคม 2553
- พัชรี ธีรจินดาจจร และคณะ. 2550. **การประเมินความอุดมสมบูรณ์ของดินโดยวิธีการวิเคราะห์ดิน**. ภาควิชาพืชศาสตร์และทรัพยากรการเกษตร คณะเกษตรศาสตร์ มหาวิทยาลัยขอนแก่น. 37 หน้า.
- สถาบันวิจัยยาง กรมวิชาการเกษตร. 2553. **ข้อมูลวิชาการยางพารา**. สถาบันวิจัยยาง กรมวิชาการเกษตร กระทรวงเกษตรและสหกรณ์, กรุงเทพฯ. 128 หน้า.

APPENDIX C

EXPERIMENT FIGURE



ภาพที่ 1 หน้าตัดดินบริเวณที่เก็บตัวอย่าง



ภาพที่ 2 สภาพแปลงทดลอง



ภาพที่ 3 วัดความสูงต้นยางพารา



ภาพที่ 4 วัดขนาดเส้นผ่าศูนย์กลางต้นกล้วย

BIOGRAPHY

NAME	Miss Thanya Uttraporn
DATE OF BIRTH	27 September 1982
PLACE OF BIRTH	Yala, Thailand
INSTITUTIONS ATTENDED	Prince of Songkla University, 2005 Bachelor of Science (Technology and Management) Mahidol University, 2011 Master of Science (Appropriate Technology for Resource and Environmental Development)
HOME ADDRESS	24 Moo.2, Ban Song, Wiang Sa District, Suratthani Province, 84190, Thailand E- mail : m_memost@hotmail.com
PRESENTATIONS	Oral presentation on “The 7 th KU – KPS Conference” 7 – 8 December 2010.