



UNIVERSITI PUTRA MALAYSIA

***EVALUATION OF TAPIOCA STARCH IN SLOW RELEASE FERTILIZER
COMPOSITION FOR RUBBER SEEDLINGS***

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APPROVAL SHEET

This project report attached here to entitled **“EVALUATION OF TAPIOCA STARCH IN SLOW RELEASE FERTILIZER COMPOSITION FOR RUBBER SEEDLINGS”** prepared and submitted by LAURA SAMSON in partial fulfilment of the requirement for the degree of Bachelor of Engineering (Agricultural and Biosystems) is hereby accepted.

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ABSTRACT

Tapioca peels is the outer layer of the tapioca roots or the skin of the tapioca roots. Starch can be extracted from tapioca peels. Tapioca was mostly to be processed into flour in flour mill region is where tapioca by-products were found. The project invention is to prove the ability of tapioca starch to reduce the utilization of NPK fertilizer amount in each polybag by controlling the thickness of coating diameter. In this project, the coating methods were applied are manual coating, sprayed with cold water, dough coating, blended using blender and mixed with mixer to produce Starch-NPK fertilizer. Then, the degradation of Starch-NPK was tested in soil. After that, the effect of Starch-NPK in rubber seedlings growth is identify. The successful coating methods are manual coating, sprayed with cold water and mixed using mixer. The degradation rate of Starch-NPK for cold water is lowest compare to degradation rate of Starch-NPK for manual coating and using mixer.

ABSTRAK

Kulit ubi kayu adalah lapisan luar dari ubi kayu atau kulit akar ubi. Kanji boleh diekstrak daripada kulit tapioka. Tapioca kebanyakannya akan diproses menjadi tepung di rantau kilang tepung di mana produk sampingan ubi didapati. Ciptaan projek ini adalah untuk membuktikan keupayaan kanji ubi guna mengurangkan penggunaan jumlah baja NPK dalam setiap polibeg dengan mengawal ketebalan diameter salutan. Dalam projek ini, kaedah salutan yang digunakan adalah salutan manual, disemur dengan air sejuk, salutan doh, dicampur menggunakan pengisar dan dicampur dengan pengadun untuk menghasilkan baja kanji-NPK. Kemudian, degradasi kanji-NPK diuji di dalam tanah. Selepas itu, kesan kanji-NPK dalam pertumbuhan benih getah akan dikenalpasti. Kaedah salutan yang berjaya adalah salutan manual, disemur dengan air sejuk dan dicampur menggunakan pengadun. Kadar degradasi kanji-NPK untuk air sejuk adalah terendah berbanding dengan kadar degradasi kanji-NPK untuk lapisan manual dan menggunakan pengadun.

TABLE OF CONTENTS

APPROVAL SHEET	ii
ACKNOWLEDGEMENT	iii
ABSTRACT.....	iv
ABSTRAK.....	v
LIST OF TABLES.....	viii
LIST OF FIGURES	ix
LIST OF ABBREVIATIONS.....	x
CHAPTER 1	1
INTRODUCTION	1
1.1 Overview	1
1.2 Problem Statements.....	2
1.3 Purpose and Research Objectives of Study.....	3
CHAPTER 2	4
LITERATURE REVIEW	4
2.1 NPK Fertilizer Based Slow Release Fertilizer.....	4
2.2 Starch Based Slow Release Fertilizer.....	5
2.3 Rubber	6
2.3.1 Rubber Management Practices	8
2.3.2 Weed Management	9
2.3.3 The Eco-Friendliness of Rubber	9
2.4 Rubber Seedlings Growth	11

CHAPTER 3	13
METHODOLOGY	13
3.1 Flow Chart.....	13
3.2 Materials.....	14
3.3 Methods.....	14
3.3.1 Preparations of Tapioca Starch.....	14
3.3.2 Coating.....	15
3.4 Degradation in Soil.....	16
3.5 Effect of Starch-NPK Fertilizer in Rubber Seedlings Growth.....	18
CHAPTER 4	20
RESULTS AND DISCUSSION.....	20
4.1 Coating Methods	20
4.2 Rate of Degradation on Soil.....	22
4.3 Effect of Starch-NPK Fertilizer on Rubber Seedlings Growth	24
CHAPTER 5	29
CONCLUSION AND RECOMMENDATION.....	29
REFERENCES	30
APPENDIX.....	33

LIST OF TABLES

Table 1 Production of Natural Rubber in 2015.....	7
Table 2 Coating NPK Fertilizer Granules.....	20
Table 3 Weight losses of the Starch-NPK fertilizer.....	23
Table 4 Degradation rate of Starch-NPK fertilizer	23
Table 5 Data set for height of the rubber seedlings that applied with Starch-NPK fertilizer	37
Table 6 Data set for height of the rubber seedlings that applied with NPK fertilizer.....	38
Table 7 Data set for leaf diameter of the rubber seedlings that applied with Starch-NPK fertilizer	39
Table 8 Data set for leaf diameter of the rubber seedlings that applied with NPK fertilizer.....	40
Table 9 Data set for stem diameter of the rubber seedlings that applied with Starch-NPK fertilizer.....	1
Table 10 Data set for stem diameter of the rubber seedlings that applied with NPK fertilizer	2

LIST OF FIGURES

Figure 1 Tapioca starch and tapioca peels	1
Figure 2 Flowchart of the project process.....	13
Figure 3 NPK fertilizer	14
Figure 4 Tapioca starch.....	15
Figure 5 Starch-NPK fertilizer was applied.....	18
Figure 6 (a) Quantity of Starch-NPK fertilizer for each of polybag; (b) Rubber seedlings;(c) Layout of the rubber seedlings.....	19
Figure 7 Outcome of the coating methods.....	22
Figure 8 Degradation Rate of Starch-NPK Fertilizer	24
Figure 9 Height Growth of Rubber Seedlings When NPK Fertilizer was Applied.....	26
Figure 10 Height Growth of Rubber Seedlings When Starch-NPK Fertilizer was Applied	26
Figure 11 Leaf Diameter Growth of Rubber Seedlings When NPK Fertilizer was Applied.....	27
Figure 12 Leaf Diameter Growth of Rubber Seedlings When Starch-NPK Fertilizer was Applied	27
Figure 13 Stem Diameter Growth of Rubber Seedlings When NPK Fertilizer was Applied.....	28
Figure 14 Stem Diameter Growth of Rubber Seedlings When Starch-NPK Fertilizer was Applied	28
Figure 15 First day of degradation test for both Starch-NPK fertilizer and NPK fertilizer. (a) Manual sample A; (b) Manual sample B; (c) Mixer sample A; (d) Cold water sample A; (e) Mixer sample B.....	33
Figure 16 Second day for degradation test on soil for Starch-NPK fertilizer.(a) Mixer sample B; (b) Mixer sample A; (c) Cold water sample B; (d) Cold water sample A; (e) Manual sample A; (f) Manual sample B	34

LIST OF ABBREVIATIONS

NPK	Nitrogen, Phosphate and Potassium
NP	Nitrogen, Phosphate
PK	Phosphate, Potassium
SAP	Superabsorbent polymer
N	Nitrogen
P	Phosphate
K	Potassium

CHAPTER 1

INTRODUCTION

1.1 Overview

Tapioca is commonly known as cassava in other country. Basically, the skins of the tapioca are the left over after the tuber have been clean by water and peeled is called as tapioca peels. The root of tapioca is made of 5% to 15% of tapioca peel. In factories region that processing tapioca into flour are where the tapioca by-products were mostly found. The amount of protein in tapioca peels is less than 6% of dry matter which indicate a low value and the crude fiber range value is 10% to 30% of dry matter which indicate that they have high and variable fiber content (Heuze, V., Tran, G., Archimede, H., Regnier, C., Bastianelli, D., & Lebas, 2016). Figure 1 showed that on the left side is tapioca starch extracted from the tapioca peels and on the right side is the tapioca peels (Figure source: Heuze, V., Tran, G., Archimede, H., Regnier, C., Bastianelli, D., & Lebas, 2016).



Figure 1 Tapioca starch and tapioca peels

1.2 Problem Statements

Fertilizer playing a big role in crop production. However, the benefits of the fertilizer cannot be fully utilized by the plant when more than half of the applied amount of fertilizer were being washed away by rain and irrigation water. The amounts of the fertilizer lost contribute to the economics loss in term of labour and fertilizer cost as well as very severe environmental pollution regarding to their decomposition (Rashidzadeh & Olad, 2014). Since tapioca starch-slow release fertiliser is needed to apply once within the polybag of seedlings, the cost of labour for fertilizer application can be reduced.

Due to the monsoon season in our country with the highest rainfall recorded at Labuan station at 4,938.9 mm and the lowest rainfall recorded at Kuala Kangsar station at 1,955.4 mm in 2017 as reported in Compendium of Environment Statistics 2018, the frequency of dispersing of NPK fertilizer was increased. The interaction between the microbe in the soil and starch makes the NPK granules fertilizer are stay in one place.

The abundance of unutilized of the tapioca peels in Indonesia is reported roughly 440 800-ton peels were produced in 2009 (Kurniawan et al., 2011) . This abundance of unused tapioca peels can be utilized as a coating agent in slow release fertilizer, in other word to transform from waste to wealth. Slow release fertilizers function is to slowly release the fertilizers to the plant that correspond with the nutrient needed of a plant and at the same time reducing the fertilizer loss (Rashidzadeh & Olad, 2014).

1.3 Purpose and Research Objectives of Study

The general objective of this study is to identify the appropriate technique for utilizing tapioca starch as NPK fertilizer granules coating.

Specific Objectives:

1. To evaluate the rate of degradation of Starch-NPK fertilizer in soil.
2. To investigate the effect of Starch-NPK fertilizer on growth of rubber seedlings.



CHAPTER 2

LITERATURE REVIEW

2.1 NPK Fertilizer Based Slow Release Fertilizer

In Malaysia, any types of farming systems use more than 90% mineral fertilizers in their farming practices. The most common fertilizers are urea, ammonium phosphate, calcium ammonium nitrate, phosphate rock, super phosphates, ammonium phosphate, potassium chloride, potassium sulphate and NPK, NP and PK compound fertilizers. Crop production increase rapidly especially of plantation crops such as rubber, oil palm and cocoa lead utilization of fertilizer is become more popular (Food and Agriculture Organization, 2004).

There are three types of fertilizers that were used for SRFs: 1) slightly soluble materials, for example urea-formaldehyde; 2) materials for deep placement, for example urea super granules; 3) coated fertilizers. Coated fertilizers are the standard fertilizers with numerous materials that reduce the dissolution rate were prepared by coating the granules of standard fertilizers (Wu, Liu, & Rui Liang, 2008).

Superabsorbent polymer can manage water intake of the fertilizer. Superabsorbent polymers are cross-linked polymers network that can take water or aqueous solution in massive amount up to hundreds of times of their weight (Olad, Gharekhani, Mirmohseni, & Bybordi, 2018); (Rashidzadeh & Olad, 2014). The application of Superabsorbent polymer in agriculture field can decrease the water consumption, reduce irrigation frequency, prolong nutrient availability in soil and improve growth rate of plant (Olad et al., 2018). The pure NPK fertilizer

can complete release the nutrient within 6 hours in water. However, superabsorbent encapsulated NPK fertilizer still releasing nutrient after one month weight (Olad et al., 2018); (Rashidzadeh & Olad, 2014).

2.2 Starch Based Slow Release Fertilizer

Starch exists as granules that inside the chloroplasts of green leaves and inside amyloplasts of storage organs for example seeds and tubers. Starch commonly can be found in potatoes, maize, wheat and tapioca. Each of these species have different properties of starch. Amylose, a fundamental linear molecule and amylopectin, a vastly branched molecule are the two principal components of starch (Ellis et al., 1998). Corn starch is widely used around the world (Lopez et al., 2014).

Coating is important for slow released fertilizer as it encapsulated physically the soluble fertilizers with hydrophobic inorganic with or without the organic materials to act as resistance to restraint the “burst effect” of fertilizers (Qiao et al., 2016). They should be tested for degradation in soil which could give bad effect to the plant when they might produce toxic substance (Han, Chen, & Hu, 2009). The popular coating materials is sulphur which is one of insoluble materials, since it could not only slow down the release of nutrients from fertilizers but also acts as secondary plant nutrients as well as neutralization agent for soil alkalinity (Qiao et al., 2016).

The other typical coating materials are the oil-based polymers such as polyethylene, polypropylene, polyvinyl chloride, polystyrene and acrylonitrile-butadienestyrene (Xiao et al., 2017). However, sulphur is being replaced by renewable biopolymers (lignin, cellulose and starch) as substitute coating materials to enhance the performance of slow-release fertilizer due

to high cost, process complexity and environmental pollution issues regarding to the petroleum-based polymers (Qiao et al., 2016).

Superabsorbent polymer (SAP) has the ability to absorb and keep a certain amount of water to form a superabsorbent hydrogel. They are three-dimensional matrix formed by hydrophilic polymers that chemically or physically linked, which gradually release the water and mixed ingredients in a dry condition. In agriculture, SAPs have been majorly utilized due to its properties as soil conditioner and nutrient carrier. Starch-based SAP (starch-SAPs) was able to surpass the traditional SAPs in term of biodegradability, renewability, abundance and low cost (Xiao et al., 2017).

One example of starch-SAPs is starch-g-polyacrylamide as a coating agent. They are able to cross-link with polyacrylamide molecule that was stable in soil with the formation of potentially toxic acrylamide. The resultant product may result an adjustable nutrient release behaviour appeared with by the desired water-retention property which effectively boost up the efficiency fertilizer application on the plant, if the fertilizer particles are being coated with starch-SAPs from different source of starch since the starch botanical origins could influence starch characteristics. Therefore, it may change the structure-property of related starch-polyacrylamides (Qiao et al., 2016).

2.3 Rubber

Rubber tree (*Hevea brasiliensis*) is a native plant of Amazon region of South America, including Brazil, Venezuela, Ecuador, Colombia, Peru and Bolivia (Zhou et al., 2015). Brazil was the top supplier of rubber latex during the nineteenth century, which the latex obtained through tapping the rubber trees that were found in natural forest. The journey of the rubber to

Malaysia begins when the seedlings were illegally taken from Brazil, where then become the parent planting stock for rubber plantations in Malaysia (Food and Agriculture Organization, 2001). Table 1 showed the total production, total area planted, total exported, total imported, domestic consumption of natural rubber, number of persons engaged in estate sector and total salaries and wages paid in estate sector in Malaysia until 2015.

Table 1 Production of Natural Rubber in 2015

Malaysia total production of natural rubber	722,122 tonnes
1. Smallholding sector	665,301 tonnes (92.1% from total production)
2. Estate sector	56,821 tonnes (7.9% from total production)
Total area planted	995733 ha
a. Smallholding sector	919,901 ha (92.4% from total area planted)
b. Estate sector	75,832 ha (7.6% from total area planted)
Malaysia exported of natural rubber	900,770 tonnes <ul style="list-style-type: none"> • China at 49.3% • Germany at 12.8% • Iran at 5.6% • U.S.A at 5.1% • Brazil at 2.4% • Other countries are 24.8%
Malaysia imported of natural rubber	957,300 tonnes mainly from: <ul style="list-style-type: none"> • Thailand at 52.9% • Vietnam at 19.7%
Domestic consumption of natural rubber	474,773 tonnes <ul style="list-style-type: none"> • Largest industry: Rubber glove industry at 349,031 tonnes (73.5%)
Number of persons engaged in estate sector	Increased by 1,499 persons to 12,056 persons

Total salaries & wages paid in estate sector	RM 186.4 million
---	------------------

(Table source: Press Release, Annual Rubber Statistics 2016, Department of Statistics Malaysia).

The rubber seeds are three-seeded capsules which are burst open when it ripens. The seeds will be scattered everywhere in 15 m radius from the trees. It may end up into floodwaters near the tree, the floating seeds then may be eaten by animals such large fish, birds or monkeys, however these animals' dispersers because they digest the seeds (Zhou et al., 2015).

2.3.1 Rubber Management Practices

During immature phase (young rubber tree) is where rubber tree face more competition compare to mature phase. It is common practice to grow rubber in plantations in association with ground cover and with intercropping. Further, in the modern cropping system, to provide the best environment for young rubber plants, field upkeep is important so that they survive in the competition. The crucial management practices during this phase:

1. Establishment of ground cover
2. Intercropping
3. Weed management
4. Mulching
5. Induction of branching
6. Pruning, and
7. Thinning

These practices are meant to reduce the immaturity period and maintain optimum plant density (Nair, 2010).

2.3.2 Weed Management

Traditionally, weed control was performed in rubber plantation through hand labor by slashing the planting strips in the first four years until the canopy was closed. Application of herbicides for weed control is restricted in dry seasons. Types of herbicides were primarily used; 1) pre-emergent (applied to soil) and; 2) post-emergent (applied on the weeds). The common herbicide products used in the plantation were paraquat (Gramoxone), 2,4-D (Fenoxone), which was broad-leaved weeds control and glyphosate (Glycel, Roundup, or Weedoff), which was grass weed control. An integrated approach to economic and effective weed management is implemented by combining manual and chemical controls (Nair, 2010).

2.3.3 The Eco-Friendliness of Rubber

Rubber is an ecofriendly and ecologically viable cash crop. Natural rubber, a deciduous forest tree, helps restoration of denuded and depleted forest lands. With rubber planted of 450 trees/ha, the canopy closes in less than 5 years. *Hevea* is a decent candidate for marginal and denuded soil afforestation. As an environmentally friendly crop, rubber mainly adds to soil conservation, soil fertility, biomass generation, nutrient cycling, and as alternative to traditional timber. The last asset is because rubber is a replacement for deforestation and a feasible option, where many of the developing countries lose a great deal of timber from forest felling, leading to climate imbalance as well as soil

degradation. Western Ghats in the southern state of Kerala in India, and Amazon forests are classical instance of this degradation of the environment owing to the loss of a lot of forest cover.

Rubber cultivation includes steps to safeguard soil against erosion and to maintain its fertility. Rubber planting in hilly land in inwardly sloping contoured terraces and digging in the terraces of silt pits reduces soil erosion. Legumes crop cultivation helps avoid soil erosion, because rubber is a surface feeder, soil binding is helped by its root system.

The suggested rubber agricultural management methods are intended to improve soil properties. During mature and immature stages, soil fertility is maintained by periodic implementation of N, P, K and Mg fertilizers. The fertilizer inputs are optimized to deliver only the necessary amount to the soil through discriminatory fertilizer suggestions. When sown between rubber plants, N-fixing leguminous cover crops such *Crotalaria juncea* greatly enhance soil fertility. The crops create organic soil material when transformed in. these build up positive impacts include soil fertility enhancement, soil physical properties enhancement, water holding capacity and improved water infiltration.

In comparison with annual crops, mature rubber requires comparatively less fertilizer input to maintain high productivity. The amount of nutrients a latex crop removes from the ecosystem is relatively small compared to other crops such as coconut or tea. Another characteristic of the rubber tree is that it is a prospective solar energy harvester with an annual biomass manufacturing capacity of about 35 tonnes of dry matter / ha / year, similar to any rapidly growing species of tropical forest tree. A plant species biomass manufacturing potential is linked to its photosynthetic capacity / unit

leaf region and the complete leaf area generated by each plant. *Hevea*'s elevated potential for biomass manufacturing makes it an outstanding candidate for energy plantation as well as a source of wood production for timber and biofuel.

The development of biomass, micro-flora, and understory vegetation in rubber plantations is similar to that in teak plantations, indicating rubber's ecological desirability in terms of habitat diversity, soil physical characteristics, and nutrient recycling. Considering the energy demands, energy is obtained mainly from sunlight through photosynthesis for the manufacturing of natural rubber, whereas non-renewable oil sources are used for the manufacturing price of synthetic rubber, which is about 11 times greater than that for natural rubber.

Natural rubber therefore has enormous potential to contribute to the energy crisis resolution cause. Similarly, as an alternative source of timber, natural rubber wood has become the primary non-forest timber resource, reducing logging pressure in rubber-growing nations on natural forests and teak plantations (Nair, 2010).

2.4 Rubber Seedlings Growth

It has been discovered that rubber plants react well to systematic manure. Proper manuring during the immature phase accelerates development, thus decreasing the unproductive phase and optimizing the mature phase productivity. The main nutrients N, P, K and Mg have beneficial impacts on development and yield, and the use of NPK significantly improves yield.

Recommendations for fertilizers were developed based on soil types for distinct areas. A regular discriminatory fertilizer recommendation system was established in the various rubber-growing areas of India based on soil and leaf assessment.

This plant has the advantage of avoiding excessive fertilizer use leading to financial benefit and decreased pollution of the environment. An embedded diagnostic and recommendation system can be used to enhance the recommendation for diagnosis and fertilizer (DFR) (Nair, 2010).



CHAPTER 3

METHODOLOGY

3.1 Flow Chart

Figure 2 showed the flow chart of the project starting from the preparation of the tapioca starch until the end of Phase 3 which is to determine the effect of the Starch-NPK fertilizer on the growth of rubber seedlings.

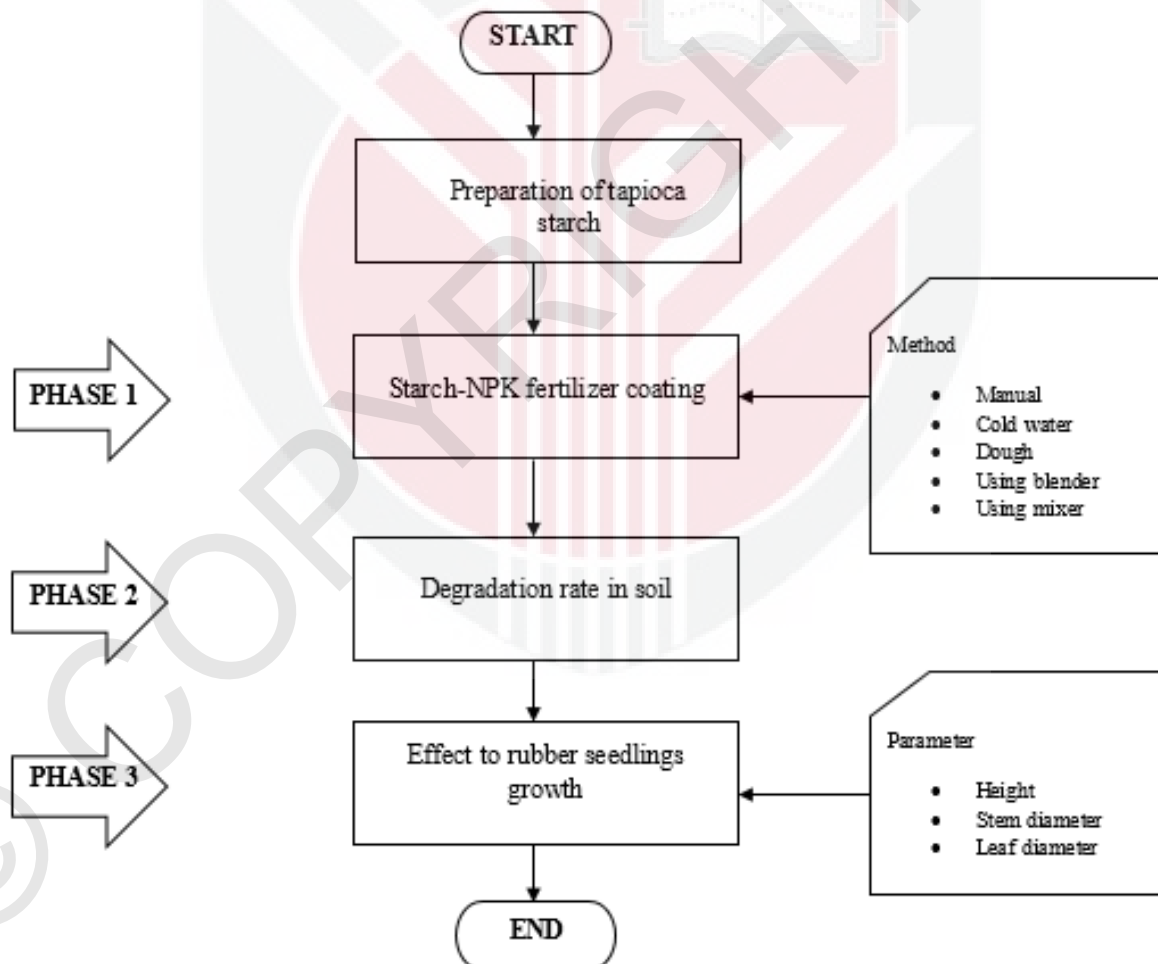


Figure 2 Flowchart of the project process

3.2 Materials

The main materials used in this project were NPK fertilizer and tapioca starch. The tapioca starch was prepared using tapioca peels. The tapioca peels were must be free from contamination such as large tubers, soil or other foreign materials. All of these contaminations must be removed to avoid the blades of blender from damage. The quality of fine mash tapioca peels was also good. The NPK fertilizer as showed in Figure 3 was provided by Dr. Harmaen Ahmad Saffian, a researcher at Institut Perhutanan Tropika dan Produk Hutan (INTROP), Universiti Putra Malaysia. The rubber seedlings were provided by Malaysian Rubber Board (MRB) at Jasin,



Figure 3 NPK fertilizer

3.3 Methods

3.3.1 Preparations of Tapioca Starch

The fresh tapioca peels were blended using blender to produce wet mash tapioca peels. Since the tapioca peels is hard, they need to be cut in small size, about 1 cm

diameter. Then, put in into blender about 5 minutes to 10 minutes until fine wet mash tapioca peels is obtained. The fine wet mash tapioca peels are spread evenly on top tray. If the wet mash is not spread evenly, the moisture in the wet mash is not evenly removed. Figure 4 showed the final product of tapioca starch.



Figure 4 Tapioca starch

3.3.2 Coating

NPK compound fertilizer granules ranging from 2.36 to 2.85 mm in diameter were sieved. During the sieving process, any granules have defects on the surface are removed. The first method is the NPK fertilizer is coated using manual method. The granules and the tapioca starch were putted in a container and was shaken. 100 grams of NPK granules and approximately 10 grams of tapioca starch were used. Second method is, the NPK fertilizer granules are dipped into cold water and quickly placed into container filled with tapioca starch with 100 grams of NPK granules and approximately 10 grams of tapioca starch were used. The container then was shaken to make the tapioca starch to coat the NPK fertilizer granules.

The third method is the tapioca starch will turn into dough. Approximately 100 grams of the NPK granules will be wrapped inside the dough and dried at room

temperature. The fourth method is the using blender to coat the NPK granules with 100 grams of NPK granules and approximately 10 grams of tapioca starch were used. The last method is using mixer to make the tapioca starch to coat the NPK granules with 300 grams of NPK granules and approximately 30 grams of tapioca starch were used. The ration for mixer is higher compare to the other due to the mixer is a bigger, the stirrer was not able to mix it if the using ratio 100 grams of NPK fertilizer and 10 grams of tapioca starch. Further, the diameter of the granules was measured before and after the coating so that the thickness of the coating was still within in the range of 1 mm.

By using Equation 1 below, the weight of the starch was used for coating was obtained:

$$S = W_1 - W_2 \text{ ----- Equation 1}$$

Where, S: Weight of the starch used for coating

W_1 : Original weight of the starch + Weight of the container

W_2 : Weight of the leftover starch after coating + Weight of container

3.4 Degradation in Soil

In determining the degradation rate of the Starch-NPK fertilizer, about 4 grams of starch-NPK fertilizer of each method were putted on the soil. The soil type is Class III as detailed in Appendix. One polybag of soil contains 4 grams one type of method of starch-NPK fertilizer and 4 grams of normal NPK fertilizer as showed in Figure 5. A strip of thin aluminium was encircled the each of type fertilizer in the polybag to avoid them from mixing together. The weight of the fertilizer was weighted with digital measuring weight. The reading of degradation of the fertilizers were recorded for three

days straight; readings were taken every day. The degradation process of everyday was showed in Figure 18 and Figure 19 in Appendix section.

Weight of the fertilizer after coating process can be calculated using Equation 2. After that, rate of degradation can be calculated using Equation 3. Following is the equations that were used in this project;

$$N = (a + c) - c \quad \text{----- Equation 2}$$

Where, N: New weight of fertilizer

a: Weight of fertilizer

c: Weight of container

$$D = \frac{W - N}{W} \times 100\% \quad \text{----- Equation 3}$$

Where, D: Rate of degradation

W: Original weight

N: New weight of fertilizer



Figure 5 Starch-NPK fertilizer was applied

3.5 Effect of Starch-NPK Fertilizer in Rubber Seedlings Growth

In determining the effect of Starch-NPK fertilizer, 4 grams as showed in Figure 6 (a) of Starch-NPK fertilizer was applied on each polybag of rubber seedlings as showed in Figure 6 (b). Then, the rubber seedlings were arranged like showed in Figure 6 (c). The data was taken on week 1, week 3, week 5 and week 7. The total polybags rubber seedlings for Starch-NPK fertilizer is 30 polybags. Meanwhile for NPK fertilizer is 6 polybags. On the day the data was taken, each of height, stem diameter and leaf diameter the rubber seedling was measured. The same parameters were recorded for NPK fertilizer.

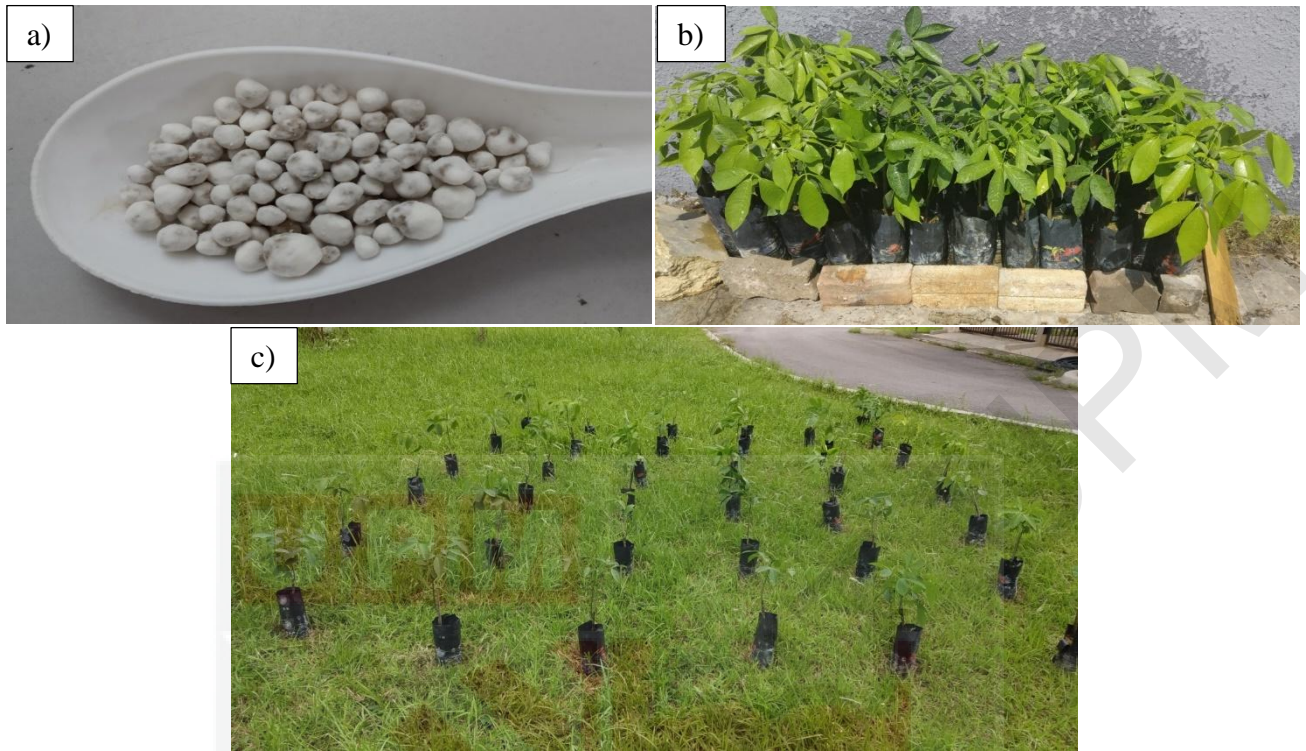


Figure 6 (a) Quantity of Starch-NPK fertilizer for each of polybag; (b) Rubber seedlings; (c) Layout of the rubber seedlings

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Coating Methods

There are five methods were identified to coat the NPK fertilizer. Table 5 showed the outcome of each of the coating methods.

Table 2 Coating NPK Fertilizer Granules

Method	Coating condition	Successfulness
1. Manual	Using this method, within 5 minutes the tapioca starch was able to fully coat each of the NPK fertilizer granules. The surface of NPK fertilizer granules were coated evenly and nicely. Figure 7 (a) showed the outcome using manual method.	Successful
2. Cold water	Using this method, within 3 minutes the tapioca starch was able to fully coat each of the NPK fertilizer granules. NPK fertilizer was easily dissolved with contact of water, sprayed with cold water within short period of time prevent it from dissolved quickly. The surface of NPK fertilizer granules were coated evenly and nicely due to the surface of the NPK fertilizer granules were wet	Successful

	<p>causing the tapioca starch to stick easily on the surface of the granules. Figure 7 (b) showed the outcome using cold water method.</p>	
3. Dough	<p>Using this method, the tapioca starch was mixed with water first to make a dough. After the tapioca starch was mixed with water, it was formed into curd-like instead forming into dough. Since one of the properties of starch is insoluble in cold water as stated by Hu et al., 2014, tapioca starch did not form into dough.</p>	Unsuccessful
4. Blender	<p>Using this method, within 5 minutes the tapioca starch was able to fully mix with NPK fertilizer. The NPK fertilizer granules were crushed by the blender blade. Attempt to form it into ball shape was failed due to mixture texture is dry. Figure 7 (c) showed the outcome using blender method.</p>	Unsuccessful
5. Mixer	<p>Using this method, within 10 minutes the tapioca starch was able to fully coat each of the NPK fertilizer granules. The surface of NPK fertilizer granules were coated evenly and nicely. Figure 7 (d) showed the outcome using cold water method.</p>	Successful

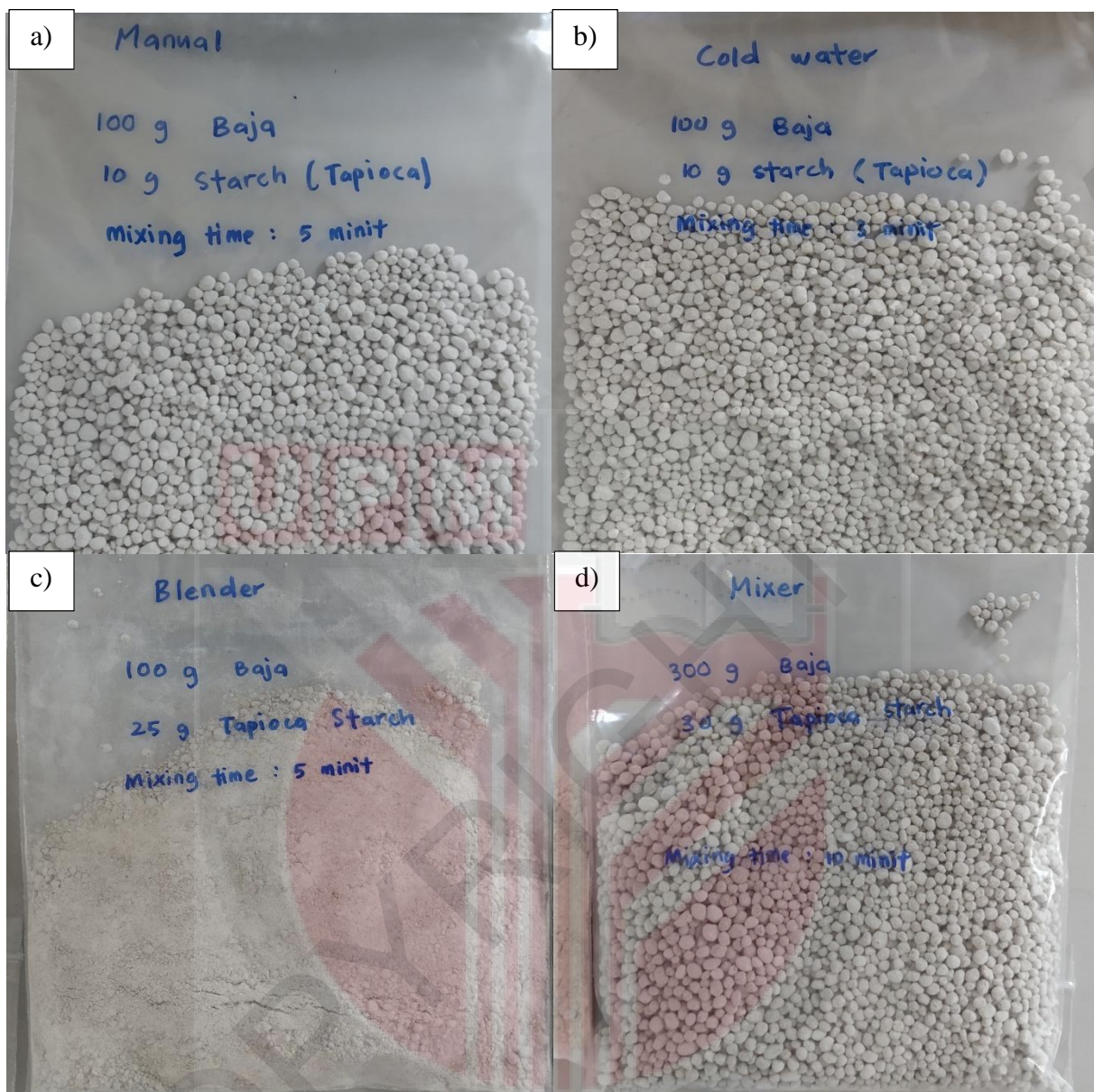


Figure 7 Outcome of the coating methods

4.2 Rate of Degradation on Soil

For degradation test, only three type starch-NPK fertilizer were tested instead of four. Since the starch-NPK fertilizer using blender method cannot shape into ball shape, the degradation rate cannot be calculated after the mixture of starch-NPK fertilizer was distributed on the soil. In Table 3, it showed the amount of Starch-NPK fertilizers were applied in each polybag with different coating methods. Based on Figure 8, degradation rate of both sample A

and B for starch-NPK fertilizer using cold water method is 20.85% and 15.83% respectively as shown in Table 4. Meanwhile for degradation rate of starch-NPK fertilizer using manual method for both sample is 33.86% and 42.16% respectively as shown in Table 4. For degradation rate of starch-NPK fertilizer using mixer method for both sample is 43.50% and 24.31% as shown in Table 4. With average fertilizer release of 18.83% on first day approaching 15% fertilizer release stated in standard of slow release fertilizers of Committee of European Normalization (CEN) (Rashidzadeh & Olad, 2014) indicate the characteristics of slow release starch-NPK fertilizer using cold water obeyed the standard.

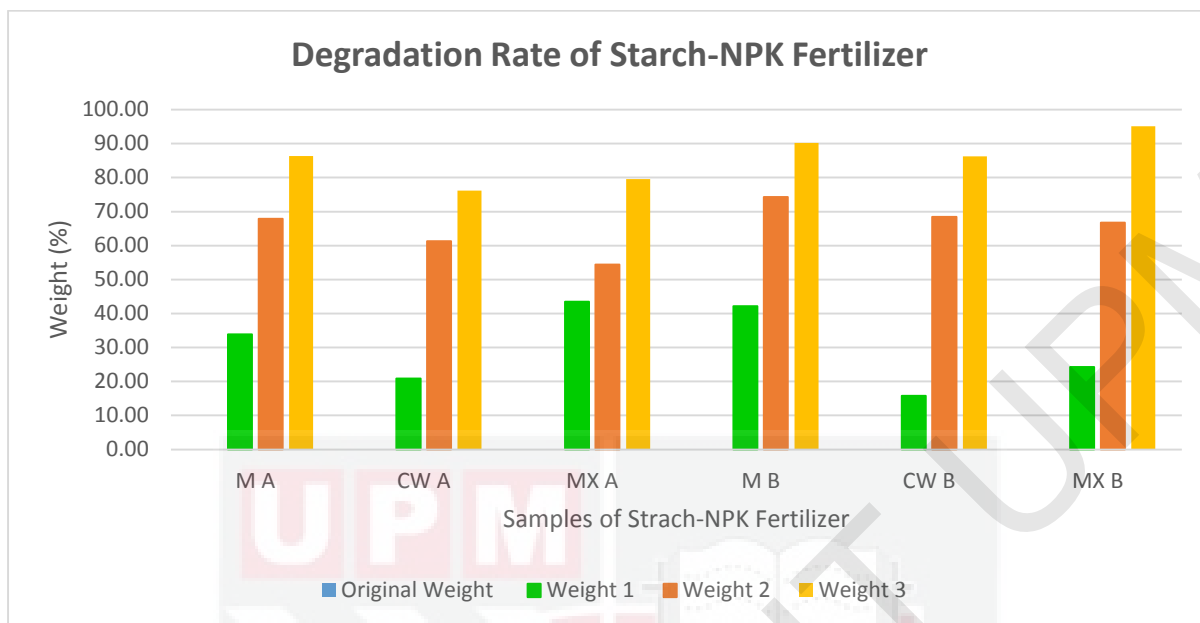
Table 3 Weight losses of the Starch-NPK fertilizer

Day	Manual (gram)		Cold Water (gram)		Mixer (gram)	
	Sample A	Sample B	Sample A	Sample B	Sample A	Sample B
*0	4.6600	4.1140	4.6700	4.2140	4.0180	4.0720
1	3.0822	2.3795	3.6964	3.5468	2.2703	3.0823
2	1.4977	1.0572	1.8076	1.3306	1.8299	1.3524
3	0.6384	0.4044	1.1130	0.5776	0.8201	0.2005

*0 is the day of fertilizers were distributed on the soil. It is the original weight of the fertilizers.

Table 4 Degradation rate of Starch-NPK fertilizer

Degradation	Manual (%)		Cold Water (%)		Mixer (%)	
	Sample A	Sample B	Sample A	Sample B	Sample A	Sample B
Original weight	0.00	0.00	0.00	0.00	0.00	0.00
Degradation 1	33.86	42.16	20.85	15.83	43.50	24.31
Degradation 2	67.86	74.30	61.29	68.42	54.46	66.79
Degradation 3	86.30	90.17	76.17	86.29	79.59	95.08



M A – Manual sample A
 CW A – Cold water sample A
 MX A – Mixer sample A
 M B – Manual sample B
 CW B – Cold water sample B
 MX B – Mixer sample B

Figure 8 Degradation Rate of Starch-NPK Fertilizer

4.3 Effect of Starch-NPK Fertilizer on Rubber Seedlings Growth

Based on Figure 10, starch-NPK fertilizer shows effect towards rubber seedlings growth based on week 7 the height of the rubber seedlings when it increased 10 cm on 8 polybags out of 30 of the rubber seedlings, compare to NPK fertilizer as control on Figure 9. The detail data for height of rubber seedlings of NPK fertilizer and starch-NPK fertilizer can be refer in the Appendix. However, starch-NPK fertilizer did not shows effect on growth of leaf of rubber seedlings based on leaf diameter shows in Figure 12, it same goes with the effect of NPK fertilizer on growth of leaf of rubber seedlings shown in Figure 11. The detail data for leaf

diameter of rubber seedlings of NPK fertilizer and starch-NPK fertilizer can be refer in the Appendix.

However, starch-NPK fertilizer shows effect on rubber seedlings growth where there is incline growth on stem diameter. Based on Figure 13 on week 7, the highest stem diameter of rubber seedlings that was applied with NPK fertilizer is 6.13 mm, meanwhile the stem diameter of rubber seedlings can growth up to 7.13 mm on week 7 showed in Figure 14 when it was applied with starch-NPK fertilizer. This indicate that the starch-NPK fertilizer was able to extend the fertilizer release duration until week 7. The detail data for stem diameter of rubber seedlings of NPK fertilizer and starch-NPK fertilizer can be refer in the Appendix.

The nutrient uptake for starch-NPK fertilizer is efficient compare to NPK fertilizer where rubber seedlings absorbed nutrient K that affect osmotic regulation, respiration, photosynthesis, stomatal movement and protein synthesis (Correia et al., 2017). Soil was able to decrease the dissolution of Starch-NPK caused the release of the fertilizer was slowed down. The rate of water exchange in the soil is low because of low free water content that trigger the fertilizer release (Olad et al., 2018).

The mechanism of fertilizer release of Starch-NPK in the polybag of rubber seedlings can be explained as follows. After the Starch-NPK fertilizer was applied in the polybag of rubber seedlings, it absorbs the available free water in soil. After that, nutrient in the fertilizer core could be gradually dissolved by water (Qiao et al., 2016).

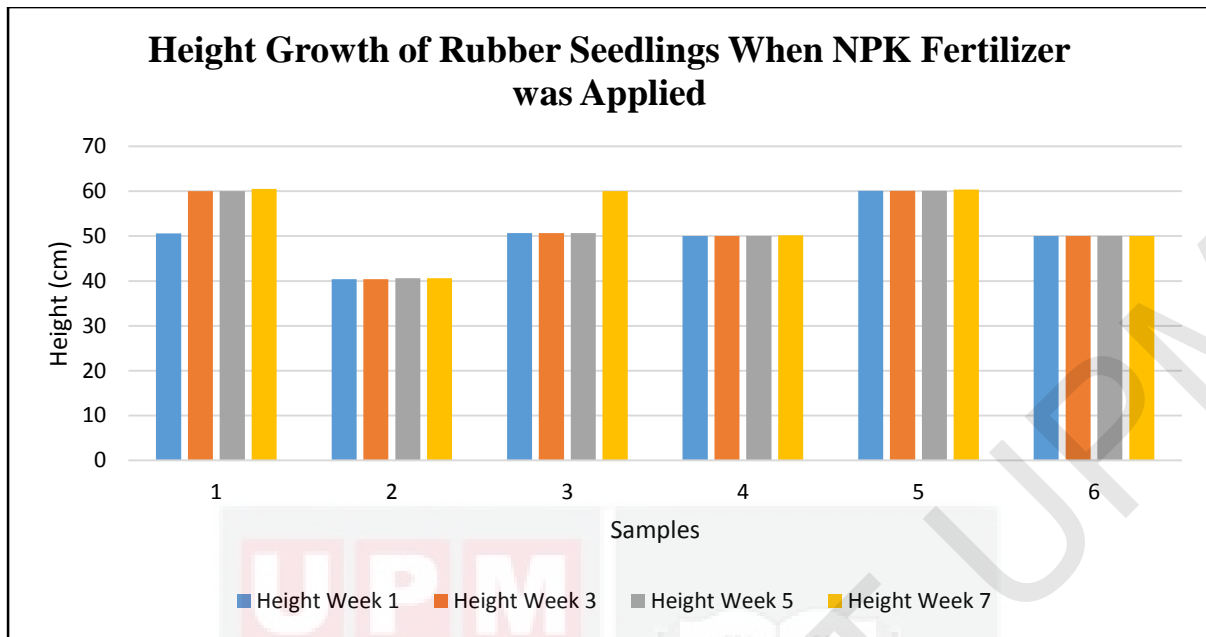


Figure 9 Height Growth of Rubber Seedlings When NPK Fertilizer was Applied

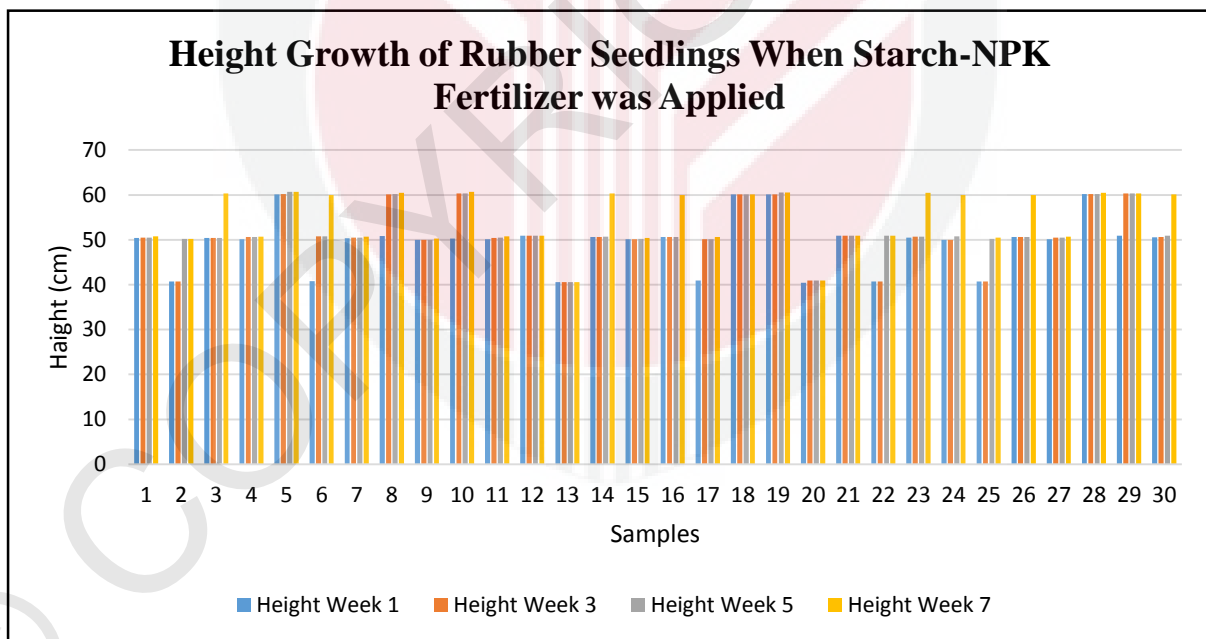


Figure 10 Height Growth of Rubber Seedlings When Starch-NPK Fertilizer was applied

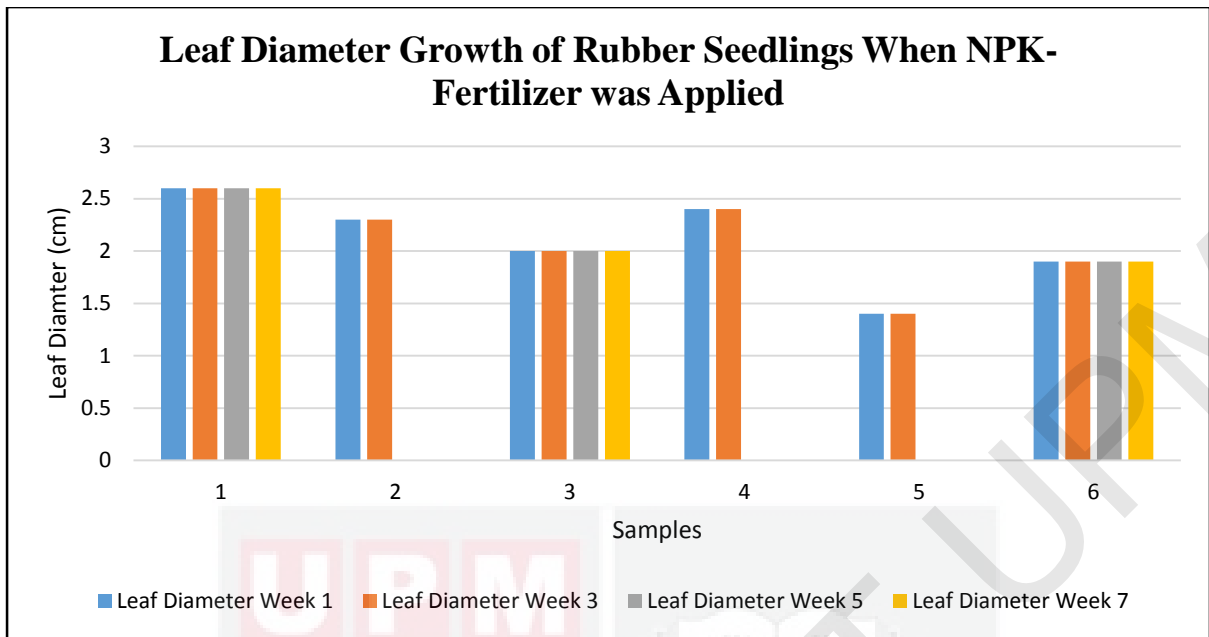


Figure 11 Leaf Diameter Growth of Rubber Seedlings When NPK Fertilizer was applied

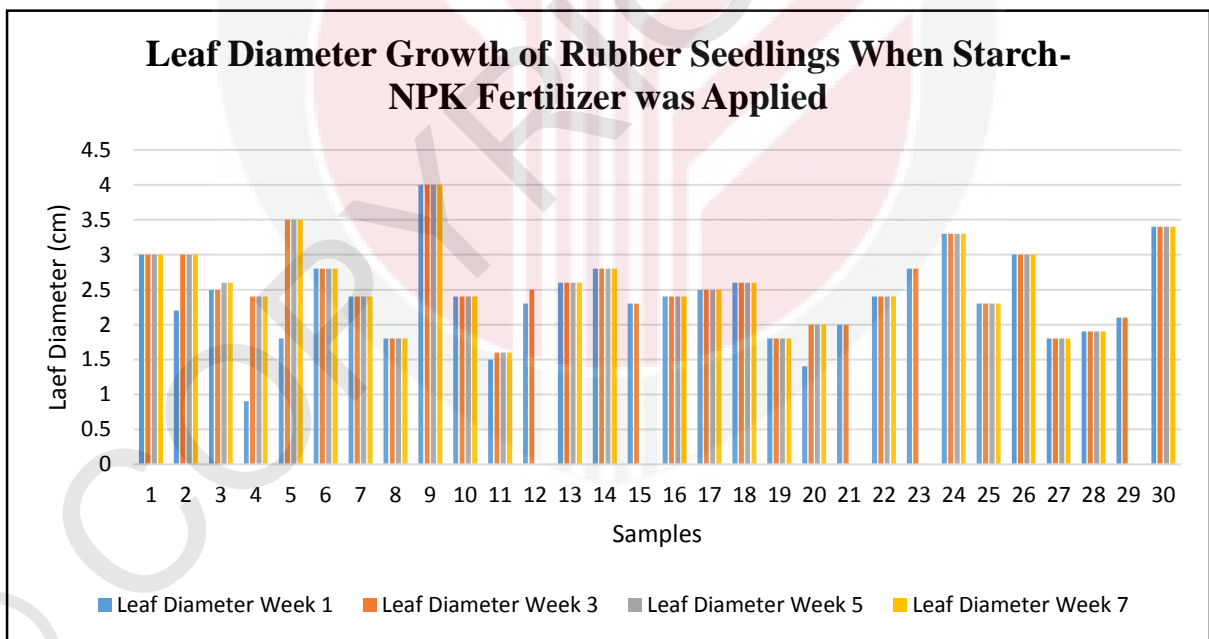


Figure 12 Leaf Diameter Growth of Rubber Seedlings When Starch-NPK Fertilizer was applied

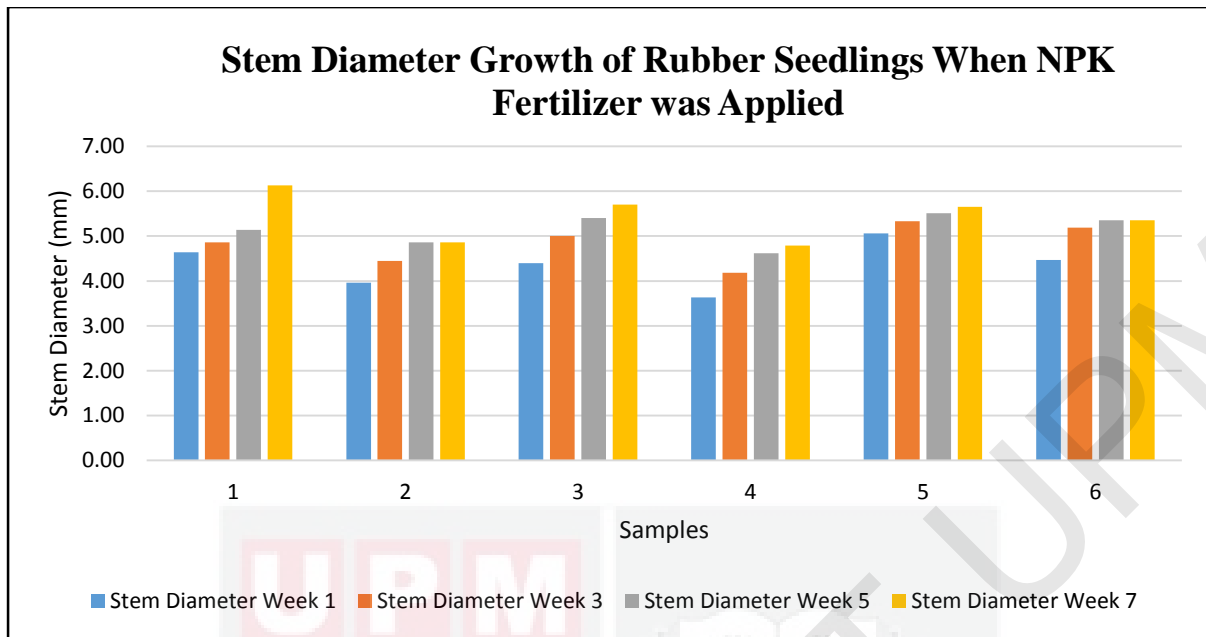


Figure 13 Stem Diameter Growth of Rubber Seedlings When NPK Fertilizer was applied

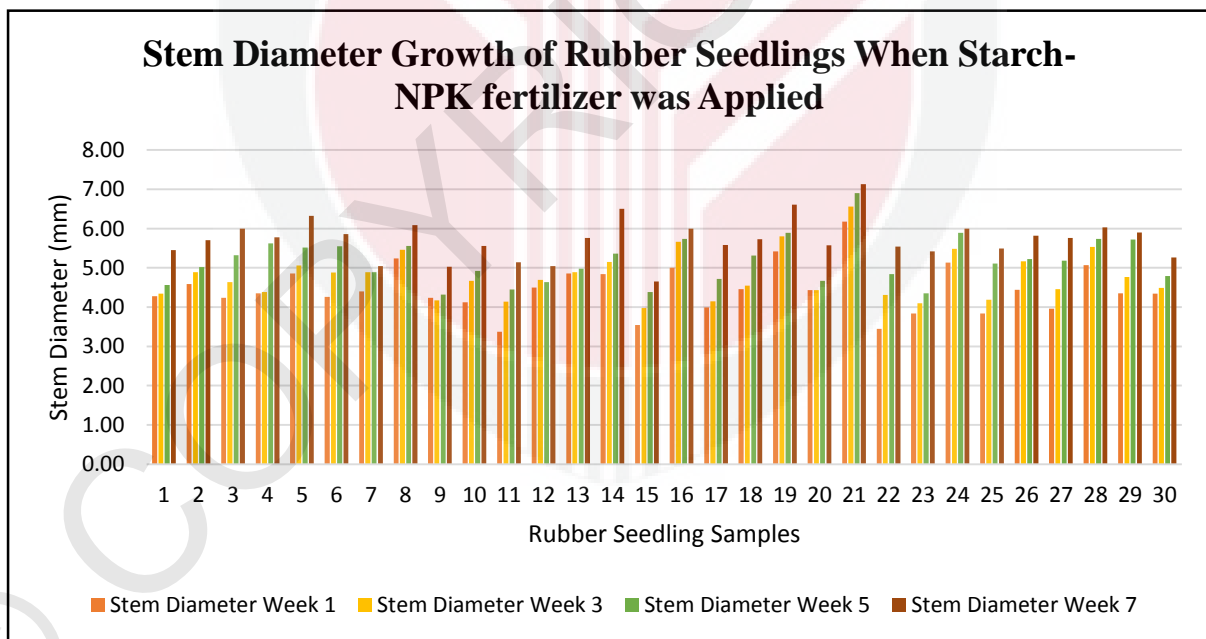


Figure 14 Stem Diameter Growth of Rubber Seedlings When Starch-NPK Fertilizer was applied

CHAPTER 5

CONCLUSION AND RECOMMENDATION

Starch-NPK fertilizer was successfully prepared by using manual coating, cold water method and mixer method in the presence of NPK fertilizer. For degradation test, starch-NPK fertilizer using cold water method indicate that the average percentage degradation rate for both samples approaching 15% fertilizer release which is obeyed the standard of slow release fertilizers of Committee of European Normalization (CEN). In 1 mm increase of granules diameter able to slow down the fertilizer release up to week 7, where the stem diameter of rubber seedlings is 6.13 mm when applied with NPK fertilizer increase up to 7.13 mm when applied with starch-NPK fertilizer.

In recommendation, this project can be improved on measuring the effect of starch-NPK fertilizer towards rubber seedlings growth. Instead of measuring the diameter of the leaf, it is better to count the number of the diameter of each of the rubber seedlings where the growth can be clearly observed based on the number of leaves.

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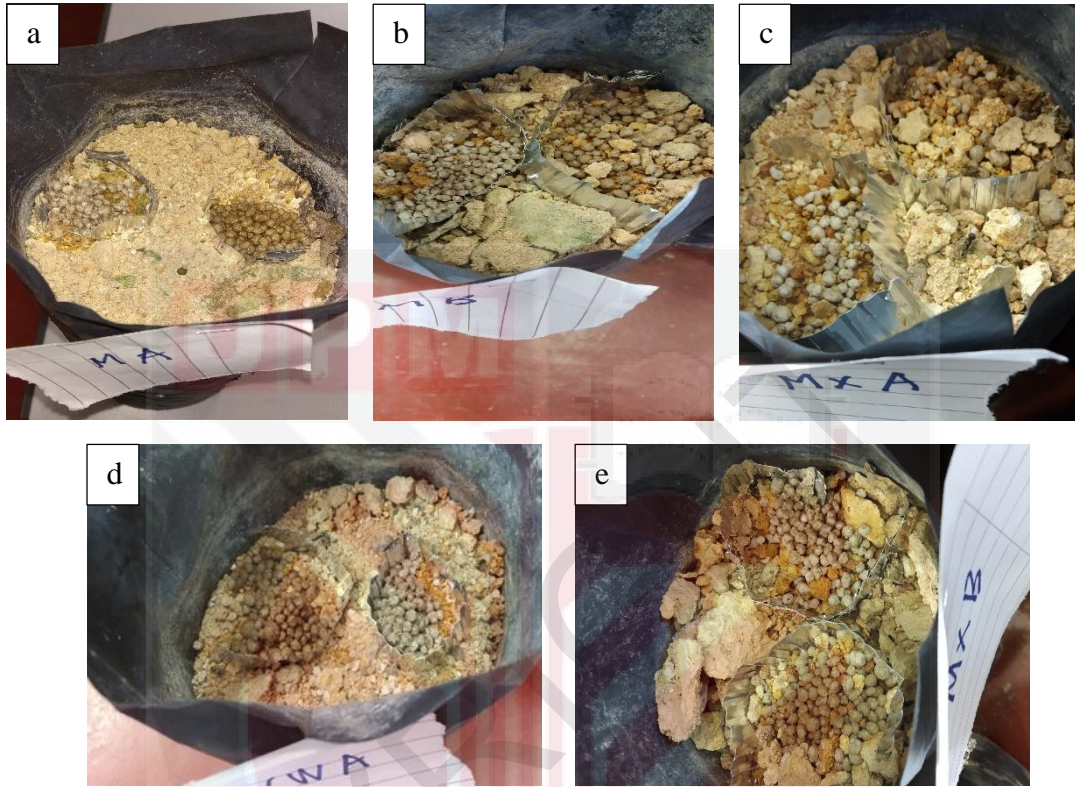
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APPENDIX



*Figure 15 First day of degradation test for both Starch-NPK fertilizer and NPK fertilizer.
(a) Manual sample A; (b) Manual sample B; (c) Mixer sample A; (d) Cold water sample A;
(e) Mixer sample B*

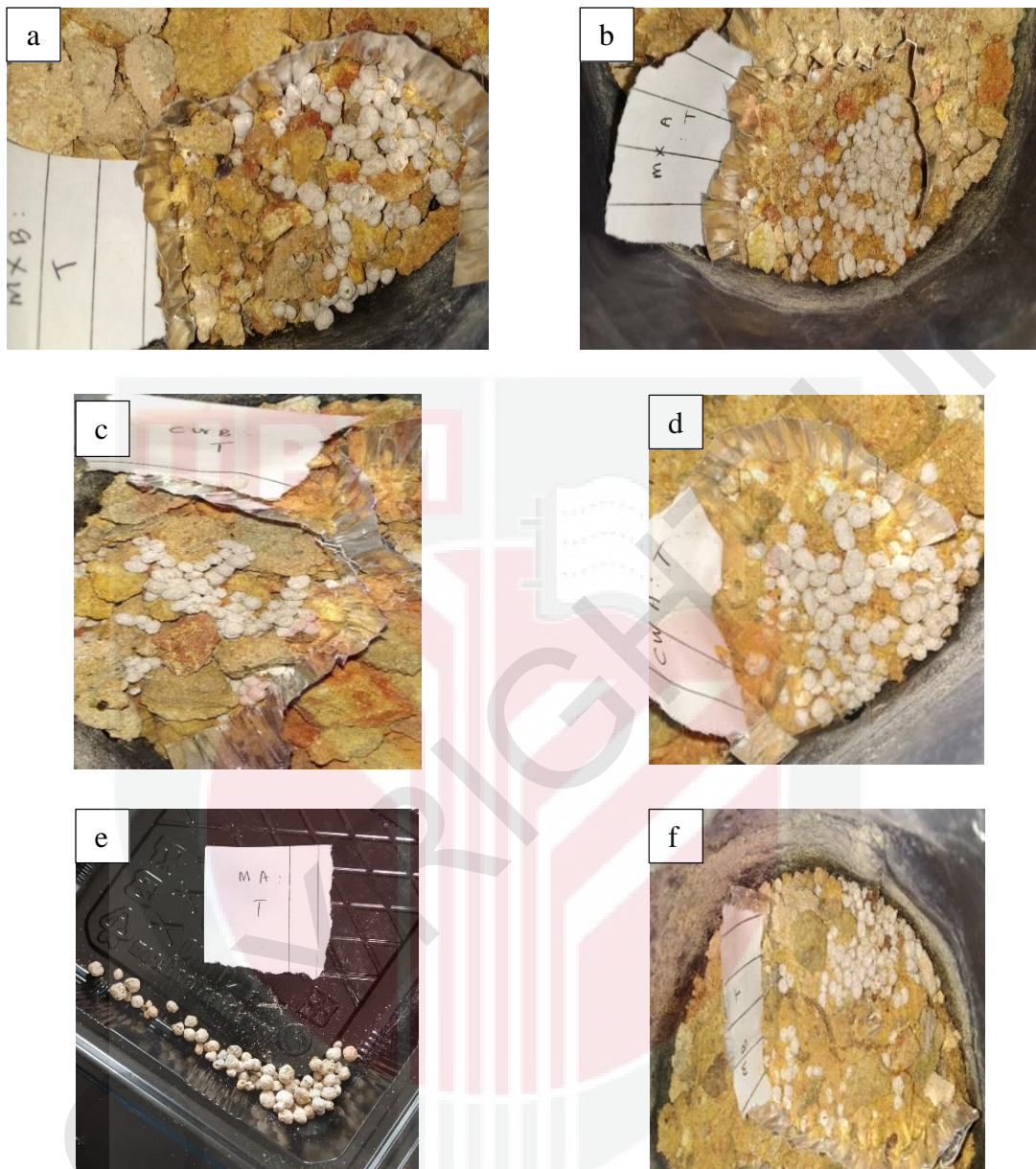


Figure 16 Second day for degradation test on soil for Starch-NPK fertilizer.(a) Mixer sample B; (b) Mixer sample A; (c) Cold water sample B; (d) Cold water sample A; (e) Manual sample A; (f) Manual sample B

Soil type: Class III

Soils in class III have severe limitations that restrict the choice plants or require special conservation practices or both. The same crop can be grown in Class III land as on Classes I and II. The area and intensity of clean cultivated land is restricted, however, to the choice of the particular crop to be used. Crops which provide soil cover, such as grasses and legumes, must find place in the rotations.

Limitations in the use of soils in Class III may be due to factors such as:

- Moderate steep slopes
- High erosion hazards
- Very slow water permeability
- Moderate depth and restricted root zone
- Low water holding capacity
- Low fertility
- Moderate alkali or salinity, and
- Unstable structure

Properties and features of Soil Class III

1. Soil characteristics	Depth of solum	Moderately deep (25 – 50 cm)
	Texture	<ul style="list-style-type: none">• Very light (sand), or• Heavy clay
	Soil drainage	Poor

2. External land features	Slope	Sloping (5 – 10%)
	Erosion	Moderate erosion
3. Environmental factors	Climate	<ul style="list-style-type: none"> • Sub-humid climate • Semi-arid climate
	Flood	For considerable period under flood
4. Present land use factors	Cultivated land	None
	Terrace land	<ul style="list-style-type: none"> • Poorly banded, and • Poorly maintained terraces

Table 5 Data set for height of the rubber seedlings that applied with Starch-NPK fertilizer

Polybag	Height of rubber seedlings: Starch-NPK fertilizer (cm)			
	Week 1	Week 3	Week 5	Week 7
1	50.4	50.5	50.5	50.75
2	40.7	40.7	50.2	50.2
3	50.4	50.4	50.4	60.3
4	50.15	50.6	50.6	50.7
5	60.1	60.2	60.7	60.7
6	40.75	50.8	50.8	60
7	50.35	50.45	50.45	50.7
8	50.85	60.1	60.2	60.45
9	50	50	50	50.3
10	50.3	60.35	60.35	60.7
11	50.1	50.4	50.5	50.8
12	50.9	50.9	50.9	50.9
13	40.6	40.6	40.6	40.6
14	50.6	50.6	50.7	60.3
15	50.1	50.1	50.2	50.4
16	50.6	50.6	50.6	60
17	40.95	50.1	50.15	50.6
18	60.1	60.1	60.1	60.1
19	60.1	60.1	60.55	60.55
20	40.4	40.9	40.9	40.9
21	50.9	50.9	50.9	50.9

22	40.7	40.7	50.9	50.9
23	50.5	50.7	50.7	60.5
24	50	50	50.8	60
25	40.7	40.7	50.2	50.5
26	50.6	50.6	50.6	60
27	50.1	50.5	50.5	50.7
28	60.2	60.2	60.2	60.5
29	50.9	60.3	60.3	60.3
30	50.55	50.6	50.9	60.1

Table 6 Data set for height of the rubber seedlings that applied with NPK fertilizer

Polybag	Height of rubber seedlings: NPK fertilizer (cm)			
	Week 1	Week 3	Week 5	Week 7
1	50.6	60	60	60.5
2	40.4	40.4	40.6	40.6
3	50.7	50.7	50.7	60
4	50	50	50	50.2
5	60.1	60.1	60.1	60.4
6	50	50	50	50

Table 7 Data set for leaf diameter of the rubber seedlings that applied with Starch-NPK fertilizer

Polybag	Leaf diameter of rubber seedlings: Starch-NPK fertilizer (cm)			
	Week 1	Week 3	Week 5	Week 7
1	3	3	3	3
2	2.2	3	3	3
3	2.5	2.5	2.6	2.6
4	0.9	2.4	2.4	2.4
5	1.8	3.5	3.5	3.5
6	2.8	2.8	2.8	2.8
7	2.4	2.4	2.4	2.4
8	1.8	1.8	1.8	1.8
9	4	4	4	4
10	2.4	2.4	2.4	2.4
11	1.5	1.6	1.6	1.6
12	2.3	2.5	0	0
13	2.6	2.6	2.6	2.6
14	2.8	2.8	2.8	2.8
15	2.3	2.3	0	0
16	2.4	2.4	2.4	2.4
17	2.5	2.5	2.5	2.5
18	2.6	2.6	2.6	2.6
19	1.8	1.8	1.8	1.8
20	1.4	2	2	2

21	2	2	0	0
22	2.4	2.4	2.4	2.4
23	2.8	2.8	0	0
24	3.3	3.3	3.3	3.3
25	2.3	2.3	2.3	2.3
26	3	3	3	3
27	1.8	1.8	1.8	1.8
28	1.9	1.9	1.9	1.9
29	2.1	2.1	0	0
30	3.4	3.4	3.4	3.4

Table 8 Data set for leaf diameter of the rubber seedlings that applied with NPK fertilizer

Polybag	Leaf diameter of rubber seedlings: NPK fertilizer (cm)			
	Week 1	Week 3	Week 5	Week 7
1	2.6	2.6	2.6	2.6
2	2.3	2.3	0	0
3	2	2	2	2
4	2.4	2.4	0	0
5	1.4	1.4	0	0
6	1.9	1.9	1.9	1.9

Table 9 Data set for stem diameter of the rubber seedlings that applied with Starch-NPK fertilizer

Polybag	Stem diameter of rubber seedlings: Starch-NPK fertilizer (mm)			
	Week 1	Week 3	Week 5	Week 7
1	4.28	4.34	4.56	5.45
2	4.59	4.89	5.02	5.70
3	4.24	4.64	5.32	6.00
4	4.35	4.38	5.62	5.78
5	4.86	5.06	5.52	6.32
6	4.26	4.88	5.55	5.86
7	4.40	4.89	4.89	5.04
8	5.24	5.46	5.56	6.09
9	4.24	4.17	4.32	5.03
10	4.12	4.67	4.92	5.56
11	3.37	4.14	4.45	5.14
12	4.50	4.69	4.64	5.04
13	4.86	4.89	4.98	5.76
14	4.84	5.15	5.36	6.50
15	3.54	3.98	4.38	4.65
16	5.00	5.66	5.74	6.00
17	3.99	4.15	4.72	5.58
18	4.46	4.55	5.31	5.73
19	5.42	5.80	5.89	6.61
20	4.43	4.43	4.67	5.57
21	6.18	6.56	6.90	7.13
22	3.45	4.31	4.84	5.54
23	3.84	4.10	4.35	5.42
24	5.13	5.48	5.89	6.00
25	3.84	4.19	5.11	5.49

26	4.44	5.17	5.22	5.82
27	3.96	4.46	5.18	5.76
28	5.07	5.53	5.74	6.03
29	4.35	4.77	5.72	5.90
30	4.34	4.49	4.79	5.26

Table 10 Data set for stem diameter of the rubber seedlings that applied with NPK fertilizer

Polybag	Stem diameter of rubber seedlings: NPK fertilizer (mm)			
	Week 1	Week 3	Week 5	Week 7
1	4.64	4.86	5.14	6.13
2	3.96	4.45	4.86	4.86
3	4.40	5.00	5.40	5.70
4	3.63	4.18	4.62	4.79
5	5.06	5.33	5.51	5.65
6	4.47	5.19	5.35	5.35