**UNIVERSITI PUTRA MALAYSIA**

# *INFLUENCE OF FERTILIZER RATES ON GROWTH OF SELECTED IMMATURE RUBBER (Hevea brasiliensis Muell. Arg) CLONES GROWN ON TWO SOIL SERIES*

**SALISU MONSURU ADEKUNLE**

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**By**

**SALISU MONSURU ADEKUNLE**

**Thesis submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree Master of Science**

**January 2014**

## DEDICATION

This thesis is dedicated to Allah, Lord of the whole universe, His Messenger, beloved companions and all other followers of the truth till the day of resurrection.

Abstract of thesis submitted to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science

**INFLUENCE OF FERTILIZER RATES ON GROWTH OF SELECTED IMMATURE RUBBER (*Hevea brasiliensis* MUELL. ARG) CLONES GROWN ON TWO SOIL SERIES**

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**SALISU MONSURU ADEKUNLE**

**January 2014**

**Chairman: Associate Professor Wan Mohamed Noordin Wan Daud, DSc**

**Faculty: Agriculture**

Knowledge of fertilizer required for (*Hevea brasilieinsis)* latex timber clones (LTC) is necessary to evaluate how fertilizer levels influence the growth and yield performance of young rubber under micro-environmental conditions. This will enable rubber industry to meet the increasing global demand of natural rubber. This study aims at evaluating the influence of fertilizer rates currently recommended by Rubber Industry Smallholders Development Authority (RISDA 1) for rubber growers in Malaysia. It is a compound fertilizer with the following composition (N10.7, P 16.6, K 9.5, Mg 2.4). This study identifies the fertilizer level that could be used in planning nutritional program for latex timber clones (LTC) *Hevea brasiliensis* at immature stage. Factorial experimental design (with two factors) was used to study forty five seedlings from three selected rubber clones planted in polybag on two different soil series (Munchong and Holyrood) each. These rubber clones (RRIM 2001, RRIM 2025 and RRIM 3001) were collected from Malaysia Rubber Board and planted in 15 x 33 cm polybags size filled with 15 kg soil. The seedlings, planted on two soils, Munchong and Holyrood (classified as Ultisols and Oxisol soils) are placed under rain shelter. The treatments consist of four fertilizer rates and a control. F1 0 g/plant (Control), F2 (78 g/plant), F3 (156 g/plant), F4 (234 g/plant) and F5

(312 g/plant) are used as treatments for each clone. Data on physiological and morphological traits such as plant height, girth size, and chlorophyll content were collected for one year. Roots image analysis for root length, root volume, average diameter and surface area were measured using WinRHIZO root scanning machine.

Foliar analysis was conducted to determine nutrient acquisition of these clones. Plant growth parameters showed that, RRIM 3001 and RRIM 2001 clones significantly responded to fertilizer rates in terms of plant girth size. In the case of RRIM 3001 increased girth size on both soils was seen when fertilizer reached maximum level of 224 g/plant. This showed that clone RRIM 3001 performed best followed by RRIM2001 and RRIM 2025. Considering the importance of girth size in rubber cultivation, fertilizer rate 224 g/plant could be recommended as optimum level for plant growth in nursery program. Foliar analysis showed that different clones require different nutrient concentrations. The clones significantly responded to increasing N, P, K and Mg. It can be deduced from the study that RRIM 3001 judiciously utilized nutrient followed by RRIM 2001. Although, all the clones except RRIM 2001 may require more P concentration when planted on both soils in order to meet its nutritional requirement. The root analysis showed that fertilizer had significant influence on the root morphological traits. It was observed that RRIM 3001 significantly responded based on all the root morphological traits measured except root surface area and root length on both soil followed by RRIM 2025. It can be concluded that RRIM 3001 had performed best in root morphological traits compared to other clones. Fertilizer recommendation by RISDA could be adopted because it facilitate root growth which help nutrients uptakes. With thorough monitoring and measurement of plants growth performance, nutrient concentration and root growth, it can be concluded that fertilizer recommendation should be based on the genetic background, soil type in a given area and other growing factors. The seedlings of latex timber clones (LTC) RRIM 3001 could be recommended on Munchong and Holyrood soil with balanced fertilizer recommendation. From this study, fertilizer rate 224 g/plant could be recommended as optimum level. However, further trial (field) needs to be to be carried on RRIM 2001, RRIM 2025 and RRIM 3001 to validate the output of this study. Finally, fertilizer rates recommended by RISDA could be adopted in nursery practices with continuous evaluation so as to meet the growth and nutritional needs of *Hevea* for both new and existing clones. This will help the industry to successfully raise advanced planting materials of natural rubber.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

**KESAN KADAR BAJAH KEATAS PERTUMBUHAN ANAK KLON GETAH (*Hevea brasiliensis* Muell. Arg) TERPILIH DITANAM DI DUA SIRI TANAH**

Oleh

**SALISU MONSURU ADEKUNLE**

**Januari 2014**

**Pengerusi: Professor Madya Wan Mohamed Noordin Wan Daud, DSc**
**Fakulti: Pertanian**

Pengetahuan baja yang diperlukan untuk *(Hevea brasilieinsis)* klon lateks balak (LTC) adalah perlu untuk menilai bagaimana tahap baja mempengaruhi pertumbuhan dan hasil prestasi getah muda di bawah syarat-syarat mikro alam sekitar. Ini akan membolehkan industri getah bagi memenuhi permintaan global yang semakin meningkat bagi getah asli. Kajian ini bertujuan untuk menilai pengaruh kadar baja pada masa yang disyorkan oleh Industri Berkuasa Kemajuan Pekebun Kecil Getah (RISDA 1) bagi penanam getah di Malaysia. Ia adalah suatu baja sebatian dengan komposisi berikut (N10.7, P 16.6, K 9.5, Mg 2.4). Kajian ini mengenal pasti tahap baja yang boleh digunakan dalam merancang program pemakanan untuk klon lateks balak (LTC) *Hevea brasiliensis* pada peringkat belum *matang.* Reka bentuk eksperimen faktorial (dengan dua faktor) telah digunakan untuk mengkaji empat puluh lima benih dari tiga klon getah terpilih ditanam di polibeg pada dua siri tanah yang berbeza (Apek dan Holyrood) setiap satu. Klon getah (RRIM 2001, RRIM 2025 dan RRIM 3001) telah diambil dari Lembaga Getah Malaysia dan ditanam di 15 x 33 cm saiz polibeg diisi dengan 15 kg tanah. Anak benih, ditanam di dua tanah, Apek dan Holyrood (diklasifikasikan sebagai ultisol dan Oxisol tanah) diletakkan di bawah perlindungan hujan. Rawatan yang terdiri daripada empat kadar baja dan kawalan. F1

0 g / pokok (Kawalan), F2 (78 g / pokok), F3 (156 g / pokok), F4 (234 g / pokok) dan F5 (312 g / pokok) digunakan sebagai rawatan untuk setiap klon. Data mengenai sifat-sifat fisiologi dan morfologi seperti ketinggian tumbuhan, saiz ukur lilit, dan kandungan klorofil yang dikumpul selama satu tahun. Analisis akar imej untuk panjang akar, jumlah akar, diameter purata dan kawasan permukaan diukur dengan menggunakan mesin pengimbas WinRHIZO akar.

Makro telah dijalankan untuk menentukan pengambilan nutrien klon-klon ini. Parameter pertumbuhan tumbuhan menunjukkan bahawa, RRIM 3001 dan RRIM 2001 klon ketara balas kepada kadar baja dari segi tumbuhan saiz ukur lilit. Dalam kes RRIM 3001 meningkat saiz lilitan di kedua-dua tanah dapat dilihat apabila baja mencapai tahap maksimum 224 g / pokok. Ini menunjukkan bahawa klon RRIM 3001 mencatatkan prestasi terbaik diikuti oleh RRIM2001 dan RRIM 2025. Memandangkan kepentingan saiz lilitan dalam penanaman getah, kadar baja 224 g / pokok boleh disyorkan sebagai tahap optimum untuk pertumbuhan tumbuhan dalam program nurseri. Makro menunjukkan bahawa klon berbeza memerlukan kepekatan nutrien yang berbeza. Klon ketara balas kepada peningkatan N, P, K dan Mg. Ia boleh disimpulkan daripada kajian ini bahawa RRIM 3001 nutrien bijaksana digunakan diikuti oleh RRIM 2001. Walaupun, semua mungkin memerlukan K penumpuan lebih apabila ditanam di Holyrood siri tanah untuk memenuhi keperluan nutrisinya. Analisis menunjukkan bahawa akar baja mempunyai pengaruh besar ke atas akar sifat-sifat morfologi. Diperhatikan bahawa RRIM 3001 dengan ketara balas berdasarkan semua akar sifat-sifat morfologi diukur kecuali kawasan permukaan akar di kedua-dua tanah diikuti dengan RRIM 2025. Ia boleh membuat kesimpulan bahawa RRIM 3001 telah dilakukan terbaik di akar ciri-ciri morfologi berbanding dengan klon lain. Cadangan Baja RISDA boleh diguna pakai kerana ia memudahkan pertumbuhan akar yang membantu nutrien uptakes. Dengan pemantauan yang teliti dan pengukuran prestasi pertumbuhan tumbuh-tumbuhan, kepekatan nutrien dan akar pertumbuhan, ia boleh membuat kesimpulan bahawa cadangan baja perlu berdasarkan latar belakang genetik, jenis tanah di kawasan tertentu dan faktor-faktor lain yang semakin meningkat. Anak benih klon lateks balak (LTC) RRIM 3001 boleh disyorkan pada Apek dan Holyrood tanah dengan cadangan baja seimbang. Daripada kajian ini, kadar baja 224 g / pokok boleh disyorkan sebagai tahap optimum. Walau bagaimanapun, percubaan lagi (bidang) perlu yang akan dibawa di RRIM 2001, RRIM 2025 dan RRIM 3001 untuk mengesahkan output kajian ini. Akhir sekali, kadar baja yang disyorkan oleh RISDA boleh diguna pakai dalam amalan nurseri dengan penilaian berterusan bagi memenuhi pertumbuhan dan keperluan pemakanan *Hevea* bagi kedua-dua klon baru dan sedia ada. Ini akan membantu industri untuk berjaya meningkatkan bahan tanaman maju getah asli.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement of the degree of Master of Science. The members of the Supervisory Committee were as follows:

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# DECLARATION

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Signature: ______________________
Name of Chairman of Supervisory Committee: ______________________

Signature: ______________________
Name of Member of Supervisory Committee: ______________________

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| | |
|---|---|
| AA | Auto Analyzer |
| AAS | Atom Absorption spectrophotometer |
| Al | Aluminium |
| ANOVA | Analysis of variance |
| ANRPC | Association of natural rubber producing countries |
| C.E.C | Cation Exchange Capacity |
| CRD | Complete Randomize Design |
| Cmol | Cent mol |
| FAO | Food Agricultural Organization |
| $H_2SO_4$ | Sulphuric acid |
| $H_2O_2$ | Hydrogen peroxide |
| IRSG | International Rubber Study Group |
| IMP | Industrial Master Plan |
| IAEA | International Atomic and Energy Agency |
| LTC | Latex Timber Clone |
| MRB | Malaysia Rubber Board |
| RISDA | Rubber Industry Smallholders Development Authority |
| MREPC | Malaysia Rubber Export Promotion Council |
| mL | Millilitre |
| NCC | National Climate Committee |
| NKEA | National Key Economic Area |
| RSR | Root: shoot ratio |
| RRIM | Rubber Research Institute of Malaysia |
| SALB | Southern American leaf blight |
| SSCT | Small scale clone trial |
| USDA | United State Department of Agriculture |

CHAPTER 1

INTRODUCTION

## 1.1 Introduction

Natural rubber (*Hevea brasilieinsis*) originated from Brazil. It could be found in the family of *Euphobiaceae* and well known for its milk substances (latex), which releases as a result of control wounding. Meanwhile, *Hevea* could not be successfully planted and commercialized in Brazil due to incessant diseases outbreak and other growing factors (Dean, 1987). This disease is popularly referred to as Southern American leaf Blight (SALB) caused by *Microcyclus ulei* (Singh, 2010). Its English name 'rubber' was given by a great scientist, Joseph Priestly in 1770 as a result of its ability to rub off pencil marks (Mokhatar *et al.*, 2012). In addition, its latex can be used for the production of more than 40,000 products, with at least 400 medical devices (Mooibroek and Cornish, 2000).

Natural rubber is predominantly found in the tropical regions of Asia, Africa and America, while the leading producing countries now are Thailand, Indonesia, Malaysia, Vietnam which produced nearly 73.87% in 2010, while Malaysia in 2010 account for 1.0 million tonnes ( (Salam and Wahid,1993; Noordin, 2011). Natural rubber is an essential commodity with yearly consumption increase of 5.8% since 1900 (Fox and Castella, 2010). The demand for natural rubber will continue till the end of decade due to the increasing demand for tyres in the automobile industries. He however, narrated the scenario in 2010 when consumption of natural rubber has been about 10.7 million tonnes for all markets (tyre and non-tyre), which was predicted to increase to 15.2 million tonnes by 2020 Evans, (2011).

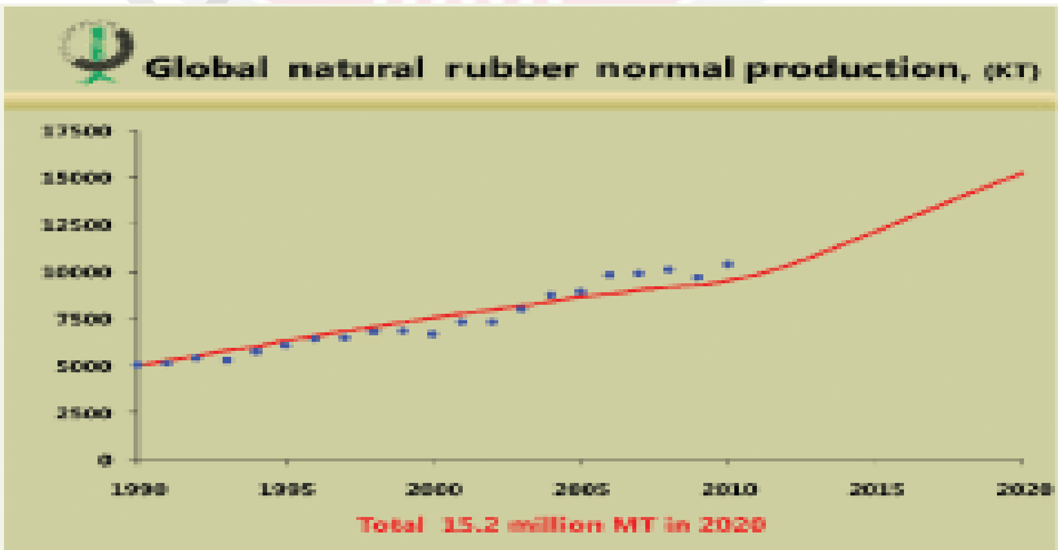


**Figure 1.1. Global Projection natural rubber production by 2020**

There are outstanding challenges which need to be addressed if natural rubber is to catch up with the global demand. Malaysia which has been the third largest producing country has mapped out different strategy by which increase in production could be achieved. To meet the set target in Malaysia rubber industry, effort on nurseries must be doubled; with enough planting materials of high yielding clones, which could meet the replanting target of 40,000 ha from the current 20,000 ha/year with the cooperation of other relevant agencies (Salmiah, 2012a).

Continuous production of natural rubber such as latex timber clones (LTC) could be sustained with adequate and appropriate agronomic inputs which will help to reduce the immaturity period and meet industrial demand (Nurul Atiqah *et al.*, 2010). Interestingly, natural rubber achieves optimum yield on appropriate soil types with balanced fertilizer recommendation (Noordin *et al.*, 1988). Replanting of natural rubber including newly developed clones requires highly weathered soils such as Ultisols and Oxisols, and fertilizer management (Yaacob *et al.*, 1992). These soils occupy about 24 million ha or 72% of the total land area in Malaysia, and they have low Cation Exchange Capacity C.E.C, high aluminium and low in most essential nutrients.

The two soil types (Ultisols and Oxisols) have been adopted and widely used in Malaysia for rubber cultivation (Mokhatar and Noordin, 2011). The soils require essential plant nutrient and good soil structure due to lack of organic matter which can supply them nutrients for plant growth (Shamshuddin and Daud, 2010). In view of this, in 1980's Malaysia Rubber Board (MRB) and Rubber Industry Smallholders and Development Authority (RISDA) that is responsible for monitoring and supply of fertilizer to rubber smallholders came up with fertilizer recommendations for rubber growers (Noordin, 2011). After this period, there were few studies that evaluated the fertilizer requirement of latex timber clones, which are newly developed (Shima *et al.*, 2007). RISDA 1 is a compound fertilizer and categorized as homogeneous product which compose (N10.7: P16.6: K9.5: Mg2.4). It is formulated in the form of pellets, granules, prills or crystals.

Different fertilizer rates are formulated by RISDA to give adequate amount of fertilizer in favour of optimum growth as well as cut the amount spent on fertilizer. Natural rubber clones require different nutrient in order to be highly productive in form of latex flow and withstand stress (Pushparajah and Tan, 1972). Adequate nutrients are needed to improve planting materials of natural rubber in order to achieve maximum yield (Yaacob *et al.*, 1992). Fertilizer is essential for rubber in the vegetative development stage (first 6 years). The country (Malaysia) must continue to improve crop yield per area with agronomic practices and soil fertility in the proper way for plantation groups and smallholders (Sabri, 2009).

## 1.2 Problem statement

The clones (RRIM 2001, RRIM 2025 and RRIM 3001) were chosen for this study because they are suitable and generously utilize fertilizer which favours early growth and tapping but they are still under evaluation as some of the clones cannot grow in certain types of soil series without adequate nutrient. For instance RRIM 3001 was found to suffer from bark burst when planted in lateritic soil. On the other hand, the performance of RRIM 2025 in different micro climates, soils and environments are not yet known. In addition, Munchong soil series (Oxisols) and Holyrood soil series (Ultisols) are reported to require more nutrients for growth and yield performance of tree crops in the tropics. Also there is the need to reduce the amount spent on fertilizer by rubber industry by determining the appropriate rate requires at the immature stage. Therefore, it is pertinent to investigate the performance of the clone regarding their response to fertilizer rates required for their optimum growth in the nurseries and in rubber estates.

## 1.2 Objectives

The study is set to achieve the general objective which is to examine the growth response of RRIM 2001, RRIM 2025 and RRIM 3001 on Ultisols and Oxisols soil series and different fertilizer rates (RISDA 1) required. The specific objectives are;

i. To evaluate the growth response of RRIM 2001, RRIM 2025 and RRIM 3001 clones in two soil series and at different fertilizer rates.

ii. To assess the effect of RISDA1 fertilizer rates recommended for rubber smallholders on different soil series.

iii. The impact of the fertilizer rates on the root morphological traits and other plant biomass of the clones.

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