UNIVERSITI PUTRA MALAYSIA

INFLUENCE OF SOILLESS POTTING MIX AND ROOT TRAINERS ON GROWTH OF RUBBER (Hevea brasiliensis Muell. Arg) Seedlings

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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 of Doctor of Philosophy

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DEDICATION

This thesis is dedicated to my family especially my lovely wife (Maryam) and my children (Asma' and Abu-bakr) for their kind support and sacrifice throughout my study.

Abstract of thesis submitted to the Senate of Universiti Putra Malaysia in fulfillment of the requirements for the degree of Doctor of Philosophy

INFLUENCE OF SOILLESS POTTING MIX AND ROOT TRAINERS ON GROWTH OF RUBBER (*Hevea brasiliensis* Muell. Arg) SEEDLING

By

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April 2017

Chairman : Associate Professor Wan Mohamed Noordin Wan Daud, Dsc
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Rubber (*Hevea brasiliensis*) is an industrial crop that contributes significantly to the nation's economy. Nursery growers frequently report a decrease in the growth of rubber seedlings due to some negative impact of soils and other planting media. Adoption of new planting techniques like the use of soilless potting mix and root trainers (container) should be considered. Thus, the purpose of the study.

In the first experiment, two newly produced soilless media, coded (M1and M2) one commercial soilless potting mix, M3 and M4 = soil-based medium as a control were evaluated with rubber seedlings. The plants grown on M1 whose composition included burnt rice husk (BRH), peat moss and urea-N (5%) increased plant stem diameter (5.5 mm/plant) and significantly different from the plants grown on M2 (3.82/plant), M3 (3.77 mm/plant) and M4 soil (3.12 mm/plant). The M1 equally gave the highest plant biomass yield. In the second experiment, the M2 whose composition included sugarcane bagasse, urea-N significantly improved scion stem diameter (6.26 mm/plant) compared to the plants grown on M1 (3.67 mm/plant), M3 (4.19 mm/plant) and M4 soil (4.42 mm/plant). Highest growth parameters like plant number of leaves, leaf area, leaf area index and plant biomass yield were significantly different $p<0.05$. There was relatively higher foliar nitrogen concentration in the plants that were grown on M2. In the third experiment, the planting media and water regimes (50%, 75%, 100% and 150% field capacity) were evaluated with rubber seedlings. The results indicated an interaction between the media and water regimes. Each of the media significantly influenced plant growth, biomass and water use efficiency (WUE). Noticeably, the growth of the plants corresponded to higher the WUEinstantaneous and WUEintrinsic whereby the M1 consistently increased plant growth such as leaf appearance rate (LAR) and biomass production and root morphological traits. Shoot dry weight of the plants was greater (14.66 g/plant) when 150% was applied and significantly different from M2 (10.36 g/plant), M3 (4.73 g/plant) and M4 6.22 g/plant. In the fourth experiment, immature rubber was evaluated with various sizes of root trainers 600 ml, 710 ml, 900 ml in volume and polybag size 15 × 20 cm designated as control. The root trainers, except for the

polybag greatly increased plant growth. The biggest container 900 ml significantly maintained a higher leaf area index (10.18) compared to the plants that were grown in 600 ml (3.32), 710 ml (2.32) and polybag (6.17). Vegetative traits were significantly influenced whereby 900 ml gave the highest total fresh weight (22.86 g/plant) and significantly different from the plants grown in the 600 ml (13.68 g/plant), 710 ml (12.99 g/plant) and polybag (13.14 g/plant). The root trainer, 900 ml had resulted in the vigorous growth of the seedlings and it could be an ideal root trainer size for raising young-green budded of rubber. The newly produced soilless potting media especially the (M1) were superior in various capacities as remarkably shown in the rubber seedlings including the budded stump. Invariably, the new planting technique (soilless and root trainer), when compared to the traditional (soil and polybag-based) planting method is ideal for raising different types of planting stocks of rubber that would ensure a sustainable growth of the plant.

Abstrak tesis dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

KESAN PEMASUAN CAMPURAN TANPA TANAH DAN PELATIH AKAR TERHADAP PERTUMBUHAN GETAH (*Hevea brasiliensis* Muell. Arg)

Oleh

SALISU MONSURU ADEKUNLE

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Getah (*Hevea brasiliensis*) adalah tanaman industri yang memberi sumbangan penting kepada ekonomi negara. Penanaman di peringkat nurseri kerap berlaku penurunan dalam pertumbuhan anak benih getah kerana beberapa kesan negatif ke atas tanah dan media tanaman lain. Penggunaan teknik penanaman baru seperti penggunaan campuran bekas tanpa tanah dan pelatih akar (bekas) perlu dipertimbangkan. Oleh itu, inilah tujuan kajian tersebut.

Dalam eksperimen yang pertama, dua media baru dihasilkan, dikodkan (M1 dan M2) iaitu satu campuran bekas tanpa tanah komersil, M3 dan M4 = media berasaskan tanah sebagai kawalan telah dinilai dengan benih getah. Pokok yang ditanam pada M1 yang terdiri daripada sekam padi bakar (BRH), tanah gambut dan urea-N (5%) meningkatkan diameter batang pokok (5.5 mm / pokok) berbanding dengan pokok yang ditanam di M2 medium lain (3.82mm / pokok), M3 (3.77 mm / pokok) dan tanah M4 (3.12 mm / pokok). Medium M1 menghasilkan biojisim tumbuhan yang tertinggi dalam hampir semua parameter yang diambil. Dalam eksperimen yang kedua, M2 yang terdiri daripada hampas tebu yang mempunyai jumlah Urea-N yang lebih tinggi menunjukkan peningkatan yang ketara ke atas diameter dahan batang pokok M2 (6.26 mm / pokok) berbanding M1 (3.67 mm / pokok), M3 (4.19 mm / pokok) dan tanah M4 (4.42 mm / pokok). Parameter pertumbuhan yang tertinggi seperti bilangan daun pokok, luas daun, dan luas indeks daun berbeza secara ketara pada nilai $p<0.05$. Kepekatan nitrogen foliar lebih tinggi dalam pokok yang ditanam di M2. Dalam eksperimen yang ketiga, media tanaman dan rejim air (50%, 75%, 100% dan 150% kapasiti lapangan) telah diuji dengan benih getah. Hasil kajian menunjukkan terdapat interaksi antara media dan rejim air. Setiap satu daripada media secara ketara mempengaruhi pertumbuhan pokok, biojisim dan kecekapan penggunaan air (Wue).Benih getah yang ditanam dalam M1 meningkat secara konsisten dalam pertumbuhan pokok seperti kadar penampilan daun (LAR) dan biojisim pokok. Berat kering pucuk yang ditanam lebih berat (14.66 g pokok^{-1}) apabila menggunakan 150% rejim air jauh lebih berat daripada M2 (10.36 g pokok^{-1}), M3 (4.73 g pokok^{-1}) dan M4 (6.22 g pokok^{-1}). Pertumbuhan pokok mencatatkan persamaan yang

lebih tinggi *WUEinstantaneous* dan *WUEintrinsic*. Dalam eksperimen yang keempat, pokok getah yang belum matang diuji dengan pelbagai saiz bekas pelatih akar iaitu 600 ml, 710 ml, 900 ml dari segi volum dan saiz polibeg 20 "× 12" telah ditetapkan sebagai kawalan. Bekas pelatih akar selain polibeg meningkatkan pertumbuhan pokok. Bekas yang paling besar 900ml menunjukkan luas indeks daun (10.18) yang tinggi berbanding dengan pokok-pokok yang ditanam di dalam bekas 600 ml (3.32), 710 ml (2.32) dan polibeg (6.17). Ciri-ciri vegetatif dipengaruhi dengan ketara di mana bekas 900 ml memberikan jumlah tertinggi berat segar (22.86 g / pokok) berbanding dengan pokok yang ditanam di dalam bekas 600 ml (13.68 g / pokok), 710 ml (12.99 g / pokok) dan polibeg (13.14 g / pokok). Bekas pelatih akar 900ml telah menghasilkan pertumbuhan rancak benih getah dan ia boleh menjadi saiz bekas yang sesuai untuk digunakan dalam meningkatkan tunas hijau muda getah. Media bekas tanpa tanah yang baru dihasilkan terutamanya media (M1) berkembang dengan lebih hebat dalam pelbagai kapasiti menunjukkan hasil luar biasa dalam anak pokok getah termasuk cantuman tunggul. Kebiasaannya, teknik penanaman baru (tanpa tanah dan pelatih akar) apabila dibandingkan dengan kaedah penanaman tradisional (tanah dan polibeg) kaedah ini adalah lebih sesuai untuk meningkatkan jenis penanaman stok getah bagi memastikan pertumbuhan mampan pokok getah.

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I certify that a Thesis Examination Committee has met on 14 April 2017 to conduct the final examination of Salisu Monsuru Adekunle on his thesis entitled "Influence of Soilless Potting Mix and Root Trainers on Growth of Rubber (*Hevea brasiliensis* Muell. Arg) Seedling" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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AAS	Atomic Adsorption Spectroscopy
AFS	Air-filled space
AW	Available water
BRH	Burnt rice husk
CEC	Cation exchange capacity
CIRP	Christmas Island rock phosphate
DTPA	diethylenetriamine Penta- acetic acid
EFB	Empty fruit bunch
EC	Electrical conductivity
FC	Field capacity
FAO	Food Agricultural Organization
IRRDB	International Rubber Development Board
ICP	Inductively coupled plasma emission spectrograph
LAR	Leaf appearance rate
LAI	Leaf area index
LTC	Latex timber clone
MRB	Malaysia Rubber Board
NoL	Number of leaves
PLHT	Plant height
PWP	Permanent wilting point
PB	Prang Besar
RRIM	Rubber Research Institute of Malaysia
RFW	Root fresh weight
RDW	Root dry weight
RSR	Root/shoot ratio
SME	Saturated media extract
SD	Stem diameter
SFW	Shoot fresh weight
SDW	Shoot dry weight
SOV	Source of variation
SQI	Seedling quality index
TOC	Total organic carbon

TPS	Total pore space
TPU	Taman Pertanian Universiti
TFW	Total fresh weight
TDW	Total dry weight
UNESCO	United Nation Educational Social Cultural Organization
USDA	United State Department of Agriculture
VWC	Volumetric water content
WUE	Water use efficiency
WHO	World Health Organization
WHC	Water holding capacity

CHAPTER 1

INTRODUCTION

Rubber (*Hevea brasiliensis*) is an indigenous plant that originated from humid tropics and has been traditionally planted in the equatorial zone within 10ºN and 10ºS; in mainland Southeast Asia which includes some parts of southern Vietnam, southern Myanmar, and southern Thailand. Major players in the rubber industry have spread across Thailand, China, Vietnam, and Malaysia. Entrepreneurs from these countries massively invest in rubber plantations in some parts of Cambodia, and Myanmar, northeast Thailand, northwest Vietnam, China, and Yunnan (Fox and Castella, 2013). The tree *Hevea* could equally successfully grow in the tropics where temperature ranges between 20 – 28ºC and where rainfall is maintained at 1,800 – 2000 mm.

It would satisfactorily grow on many soils provided it contains adequate nutrient and is well-drained. The tree grows well up to 600 meters above sea level. However, sustainable management of rubber at all growing stages is a requirement and a major concern for the development of rubber industry. This includes a regular monitoring of the environmental conditions and soil fertility among other factors especially in the tropics (Cheng *et al.,* 2007). As such, soils used for rubber in the tropical Asian countries have been categorized as having low organic carbon content and highly weathered as a result of overutilization in the last 100 years (Dharmakeerthi *et al.*, 2012).

Many soils used in Malaysia in the plantations including rubber require a lot of fertilizer for adequate support of plant growth (Shashudeen, 2010). Another challenge is the type of planting medium (container) like polybags used in nurseries. These poses more threat to plants during growth. For instance, traditional poly bags and soils cause serious damages to plants due to heavy and poor drainage. It equally suppresses plant root system (Beattie and White, 1993). In view of this, a soilless growing system, especially for young plants, may be considered as an alternative growing medium to the soil (Van and Postma, 2000) while root trainers could be used to replace polybags. Soilless medium helps to prevent root-infecting pathogen related problems. Soilless techniques in most greenhouses have been in practice for most plants including nursery trees. This is due to its superior physicochemical characteristics coupled with lower infestation rate of pathogenic pests at the initial stage.

Plant fertilization and irrigation are equally easy to satisfy under this system (Raviv *et al.*, 2002). As a result, many rubber producing countries such as Thailand, India, Sri Lanka, Vietnam, Indonesia are adopting root trainers and soilless as planting medium of *Hevea* seedlings. Nursery trees planted in containers received low attention in the tropics. This leads to poor root development (Miller and Jones, 1995).

Figure 1.1 : Rubber seedlings propagated by seeds and by budded stumps in soilless and root trainers

Furthermore, plants that are grown in commonly used polybags and soils, immediately become strangled and distorted as a result of root coiling especially when the root reaches the lower part of the polybag (Ginwal *et al.,* 2001; Soman and Saraswathy Amma, 1999). Despite these obvious defects, rubber nursery growers in the country (Malaysia) still depend largely on these planting media while other countries such as Indonesia have begun to adopt or integrate the new system for better growth of the plant. The new system enhances the early growth of rubber tree with additional advantages over the traditional system of planting. The advantages include a lesser area for production of planting stock, free from root coiling, reasonable survival percentage and growth rates are better in the field. Considering the practical convenience and cost involved soilless potting mix and root trainer one- whorl plant had proved to be an ideal planting material for commercial planting of *Hevea* (George *et al.,* 2012).

1.1 Problem statements

In Malaysia rubber nursery sector, the use of the soilless medium and root trainers (planting container) for rubber seedlings has not been widely adopted in many rubber nursery establishment. This is due to inadequate locally formulated medium coupled with other factors such as technical know-how, cost, and availability for rubber nursery growers. In addition, limited modern root trainer (Container) is another important factor militating against adoption of the planting technique. Meanwhile, lateral roots of rubber grown in the currently used traditional (polybags and soils) method usually grow in all possible directions and getting entangled in a mess. This leads to poor growth when seedlings are transplanted to the field throughout trees lifespan.

1.2 Objectives of the study

In the scientific world today, soilless production of the plant is still relevant, and appreciable studies have been conducted but lots of questions still remain unanswered. The main objective of this study is to determine seedlings of *Hevea brasiliensis* raised in root trainers with the newly produced soilless potting mixes which could provide best possible conditions for a better growth. While general objectives are;

i. To evaluate the effect of different soilless media on growth and physiological traits of rubber (*Hevea brasiliensis*) seedlings.
ii. To determine the influence of soilless potting mix on growth and vegetative traits of rubber (*Hevea brasiliensis*) budded stumps.
iii. To determine the influence of soilless media and irrigation water on growth, biomass yield and water use efficiency of rubber (*Hevea brasiliensis*).
iv. To determine the effects of different size of root trainers on growth characteristics of immature rubber (*Hevea brasiliensis*).

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