UNIVERSITI PUTRA MALAYSIA

GROWTH PERFORMANCE OF Magnolia champaca (L.) Baill. ex Pierre USING DIFFERENT TYPES OF MULCHING AT MONTANE RAINFOREST IN CAMERON HIGHLANDS, PAHANG, MALAYSIA

WAHIDULLAH RAHMANI

FPAS 2021 18

GROWTH PERFORMANCE OF *Magnolia champaca* (L.) Baill. ex Pierre USING DIFFERENT TYPES OF MULCHING AT MONTANE RAINFOREST IN CAMERON HIGHLANDS, PAHANG, MALAYSIA

By

WAHIDULLAH RAHMANI

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

March 2021

DEDICATION

My humble effort I dedicated to

My sweet and loving parents
Habibullah Rahmani and Mrs. Hanifa Zewari

My siblings
Mr. Zabiullah Rahmani and Mr. Najibullah Rahmani
for the overwhelming support and enormous sacrifices

My supervisory committee
Professor. Gs. Dr. Mohamad Azani Alis, Associate Professor Dr. Mohamad Nazre Saleh and Associate Professor Dr. Mohd Zaki Hamzah
for valuable opportunities and unconditional support

the Ministry of Higher Education and Higher Education Development Pogram
for your support

other people who involved directly and indirectly in my MSc journey
but not mentioned.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

GROWTH PERFORMANCE OF *Magnolia champaca* (L.) Baill. ex Pierre USING DIFFERENT TYPES OF MULCHING AT MONTANE RAINFOREST IN CAMERON HIGHLANDS, PAHANG, MALAYSIA

By

WAHIDULLAH RHANMANI

March 2021

Chairman : Associate Professor Mohamad Azani bin Alias, PhD
Faculty : Forestry and Environment

Tropical Montane Cloud Forest (TMCF) is one of the ecosystems most threatened by deforestation, fragmentation and global climate change. The study conducted on Sg. Terla A at Forest reserved Cameron Highlands with mean elevation 1478m above sea level. The objectives of this study are; (i) to determine the growth performance and biomass of Magnolia champaca planted under different types of mulching at the degraded area, and (ii) to determine the effect of different types of mulching on soil properties at degraded area. In this study Randomized Complete Block Design (RCBD) was used. The data on growth performance were taken since July 2019 until July 2020. The plant was measured for above and below biomass. The soil samples were taken to study the effect of different mulching materials on the soil characteristic. The results in this study showed that mulching had no significant effect on plant height, diameter breast height, and root collar diameter, and chlorophyll content between treatments. Although oil palm mulching treatment had a greater effect on plant height, root collar diameter and diameter breast height growth among treatments. Mulching showed a significant effect on root diameter and main root length among treatments. Root direction towards to sun direction among plants was varied. The root horizontal and vertical were significant difference between treatments while coconut treatment showed the highest value and oil palm showed the lowest among treatments. Mulching had no significant effect on root shoot ratio among treatments. Compared between treatments, oil palm treatment was significantly higher than other treatments. Furthermore, 75% of plants had coiling while 25% had no coiling. Dry biomass fraction was not showed significant differences between stem, branch, leaf and root in coconut, oil palm, plastic and control treatments. The highest value of roots, leaves and branches were found in coconut treatment while the lowest was found in control treatment. The highest amount of stem was found in coconut and the lowest was found in oil palm treatment. There was no significant difference for dry above and below biomass between treatments. The highest amount of above and

below biomass was found in coconut while the lowest value was found in oil palm among treatments. Moreover, soil compaction showed a significant difference between treatments. The maximum value showed in the control treatment while the minimum value was found in the coconut mulching treatment. Furthermore, the soil texture was clay 20%, silt 60 %, and 20 % sand for all treatments. Mulching had a significant effect on soil pH. The minimum pH value (4.28 pH) was recorded in plastic mulching, and the maximum value (4.57 pH) was found in coconut mulching treatment. Mulching had a highly significant effect on soil moisture content. The maximum value (17.92 %) was recoded in plastic while the minimum was showed in oil palm mulching (16.12 %) treatment. Mulching did not show a significant effect on soil organic carbon, soil organic matter, soil total nitrogen, and soil available phosphorus and topsoil and subsoil between treatments. However, mulching showed a strongly significant effect on exchange potassium and soil sulfur among treatments while topsoil and subsoil did not show a significant effect between treatments. In conclusion, the results indicate that different types of mulching have no significant effect on tree growth rate although it improves the growth rate, root development, biomass, and soil properties on the degraded areas.

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

KADAR PERTUMBUHAN *Magnolia champaca* (L.) Baill. ex Pierre MENGGUNAKAN JENIS SUNGKUPAN BERBEZA DALAM HUTAN MONTAIN DI CAMERON HIGHLANDS, PAHANG, MALAYSIA

Oleh

WAHIDULLAH RHANMANI

Mac 2021

Pengerusi : Profesor Madya Mohamad Azani bin Alias, PhD
Fakulti : Perhutanan dan Alam Sekitar

Hutan Hujan Montane Berawan adalah salah satu ekosistem yang paling terancam oleh penebangan hutan, pemecahan dan perubahan iklim global. Kajian pertumbuhan Magnolia champaca telah dijalankan di Hutan Simpan Sg. Terla A di Cameron Highlands pada ketinggian 1478m dari aras laut. Objektif kajian ini adalah; (i) untuk menentukan kadar pertumbuhan dan biomas bagi Magnolia champaca yang ditanam menggunakan pelbagai jenis sungkupan di kawasan terosot, dan (ii) untuk menentukan kesan terhadap ciri tanah yang menggunakan pelbagai jenis sungkupan di kawasan terosot. Dalam kajian ini, Reka Bentuk Blok Lengkap Rawak (RCBD) digunakan. Data prestasi pertumbuhan diambil sejak Julai 2019 hingga Julai 2020. Pokok ini diukur bagi mendapatkan biomas atas dan bawah tanah. Manakala sampel tanah diambil untuk mengkaji pengaruh bahan sungkupan yang berbeza terhadap ciri tanah. Hasil dalam kajian ini menunjukkan bahawa sungkupan tidak berpengaruh secara signifikan terhadap ketinggian pokok, diameter paras dada, dan diameter kolar akar, dan kandungan klorofil antara rawatan. Di antara rawatan yang diberikan, sungkupan kelapa sawit mempunyai pengaruh yang lebih besar terhadap ketinggian pokok, diameter kolar akar dan pertumbuhan ketinggian paras dada. Sungkupan menunjukkan kesan yang signifikan terhadap diameter akar dan panjang akar utama di antara rawatan. Arah akar menuju ke arah matahari di antara pokok adalah berbeza-beza. Akar mendatar dan menegak menunjukkan perbezaan yang signifikan antara rawatan, sementara rawatan sungkupan kelapa menunjukkan nilai tertinggi dan rawatan sungkupan kelapa sawit menunjukkan yang terendah di antara rawatan. Sungkupan tidak mempunyai pengaruh yang signifikan

terhadap nisbah tunas akar antara rawatan. Jika dibandingkan dengan rawatan, rawatan sungkupan kelapa sawit jauh lebih tinggi daripada rawatan lain. Selanjutnya, 75% pokok mempunyai akar berpintal dan hanya 25% adalah tidak. Pecahan biomas kering tidak menunjukkan perbezaan yang signifikan antara batang, cabang, daun dan akar pada rawatan sungkupan kelapa, kelapa sawit, plastik dan kawalan. Nilai tertinggi bagi akar, daun dan ranting dijumpai dalam rawatan sungkupan kelapa sementara yang terendah didapati dalam rawatan kawalan. Nilai batang paling banyak dijumpai dalam rawatan sungkupan kelapa dan yang paling rendah dijumpai dalam rawatan sungkupan kelapa sawit. Tidak terdapat perbezaan yang signifikan untuk biomas kering atas dan bawah. Jumlah tertinggi biomas atas dan bawah terdapat dalam rawatan sungkupan kelapa sementara nilai terendah terdapat di rawatan sungkupan kelapa sawit. Selain itu, pemadatan tanah menunjukkan perbezaan yang signifikan antara rawatan. Nilai maksimum ditunjukkan dalam rawatan kawalan, sementara nilai minimum didapati dalam rawatan sungkupan kelapa. Selanjutnya, tekstur tanah adalah tanah liat 20%, kelodak 60%, dan pasir 20% untuk semua rawatan. Sungkupan mempunyai pengaruh yang signifikan terhadap pH tanah. Nilai pH minimum (4.28 pH) dicatat dalam rawatan sungkupan plastik dan nilai maksimum (4.57 pH) dijumpai dalam rawatan sungkupan kelapa. Sungkupan mempunyai kesan yang sangat ketara terhadap kandungan lembapan tanah. Nilai maksimum (17.92 %) direkodkan dalam rawatan sungkupan plastik sementara nilai minimum (16.12 %) ditunjukkan dalam rawatan sungkupan kelapa sawit. Sungkupan tidak menunjukkan kesan yang signifikan terhadap karbon organik tanah, bahan organik tanah, jumlah nitrogen tanah, dan tanah yang terdapat fosforus dan tanah atas dan tanah antara rawatan. Walau bagaimanapun, sungkupan menunjukkan kesan yang sangat ketara terhadap pertukaran kalium dan sulfur tanah di antara rawatan, sementara tanah atas dan tanah bawah tidak menunjukkan kesan yang signifikan antara rawatan. Sebagai kesimpulan, hasilnya menunjukkan bahawa pelbagai jenis sungkupan tidak berpengaruh signifikan terhadap kadar pertumbuhan pokok walaupun meningkatkan kadar pertumbuhan, pengembangan akar, biomas, dan sifat tanah di kawasan yang terosot.

ACKNOWLEDGEMENTS

Alhamdulillah, all praises to Allah S.W.T., The greatest and the most merciful for his guidance and blessing, because without it I cannot finish this research. This dissertation would not have been possible without the guidance and the help of several individuals who in one way or another contributed and extended their valuable assistance in the preparation and completion of this study.

First and foremost, my utmost gratitude to my main supervisor Associate Prof Dr. Mohamad Azani Alias whose sincerity and encouragement I will never forget. I would like to express my sincere appreciation to him for his continued support of my Master's study and research, for his patience, motivation, enthusiasm, and immense knowledge.

I could not have imagined having a better mentor and advisor for my study. I also would like to thank my co-supervisors Associate Prof. Dr. Zaki Hamzah and Associate Prof. Dr. Mohamad Nazre Saleh for their advice, and valuable feedback throughout my master's study.

My sincere thanks also go to Dr. Pataya and Mr. Fakri for their assistance, guidance, and help during my fieldwork and study. My appreciation also extends to all academic and non-academic members of the faculty of Forestry and environmental science for their kind cooperation during my stay in Universiti Putra Malaysia. Heartleaf acknowledgment is expressed to my family without their support, guidance, advice, and encouragement I may have never overcome this long journey in my studies. I also would like to thank my colleagues, friends, and all people that directly or indirectly helped me to finish my thesis.

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

Mohamad Azani bin Alis, PhD
Associate Professor
Faculty of Forestry and Environment
Universiti Putra Malaysia
(Chairman)

Mohamad Nazre bin Saleh @ Japri, PhD
Associate Professor
Faculty of Forestry and Environment
Universiti Putra Malaysia
(Member)

Mohd Zaki bin Hamzah, PhD
Associate Professor
Faculty of Forestry and Environment
Universiti Putra Malaysia
(Member)

_____
ZALILAH MOHD SHARIFF, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 14 October 2021

Declaration by graduate student

I hereby confirm that:

- this thesis is my original work;
- quotations, illustrations and citations have been duly referenced;
- this thesis has not been submitted previously or concurrently for any other degree at any other institutions;
- intellectual property from the thesis and copyright of thesis are fully-owned by Universiti Putra Malaysia, as according to the Universiti Putra Malaysia (Research) Rules 2012;
- written permission must be obtained from supervisor and the office of Deputy Vice-Chancellor (Research and Innovation) before thesis is published (in the form of written, printed or in electronic form) including books, journals, modules, proceedings, popular writings, seminar papers, manuscripts, posters, reports, lecture notes, learning modules or any other materials as stated in the Universiti Putra Malaysia (Research) Rules 2012;
- there is no plagiarism or data falsification/fabrication in the thesis, and scholarly integrity is upheld as according to the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) and the Universiti Putra Malaysia (Research) Rules 2012. The thesis has undergone plagiarism detection software.

Signature: _____ Date: _____

Name and Matric No.: Wahidullah Rahmani GS53138

Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) are adhered to.

Signature: _____
Name of Chairman of Supervisory Committee: Mohamad Azani Alis

Signature: _____
Name of Member of Supervisory Committee: Mohamad Nazre Saleh

Signature: _____
Name of Member of Supervisory Committee: Mohd Zaki Hamzah

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 General Background

Mountains support 23 percent of the global's forests and 12 percent of the world's population. Tropical montane forests contain rare and varied biota and are considered to be highly vulnerable to climate change, especially near the Trade Wind Inversion (TWI) at the top of the cloud belt representing the [1]Tropical Montane Cloud Forest (TMCF) (Crausbay et al., 2015).

[2]Tropical Montane Forests (TMFs), described as forests between 23.5 ° ° N and 23.5 ° S above 1000 m above sea level, with low annual average temperatures of 10-18 °C and making up 8 % of the world's tropical forests by planimetric region (Spracklen et al., 2016). Malaysia has 2.4 million hectares of tropical mountain forests out of 19.3 million hectares of total forest cover. Eight (8) mountain ranges are present in Peninsular Malaysia, including Nakawan, Kedah-Singgora, Bintang, Keledang, Titiwangsa, Benom, Tahan, and Timur. Collectively, these highlands make up nearly 20% of the Peninsular Malaysia land area (Ahokumpu et al., 2014).

The altitudinal vegetation classifications in Malaysia are Lowland Dipterocarp Forests (0-300 m), Hill Dipterocarp Forests (300-750 m), Upper Dipterocarp Forests (750-1,200 m), Lower Montane Forests/Montane Oak Forests (1,200-1,500 m), Upper Montane Forests/Montane Ericaceous Forests (1,500-3,000 m) (Kueh et al., 2017). Common tree families in montane forests include Myrtaceae, Ericaceae, Fagaceae, Coniferae, and Lauraceae, which are also covered with epiphytes, ferns, bryophytes, and liverworts (Kumaran et al., 2011). Malaysia's montane and sub-montane forests vary in their appearance, structure and flora and faunal composition according to elevation. Lower montane forest is gradually beginning to replace hill dipterocarp forest at about 1,200 to 1,500

[1] Tropical Montane Cloud Forest (TMCF), is a generally tropical or subtropical, evergreen, montane, moist forest characterized by a persistent, frequent or seasonal low-level cloud cover, usually at the canopy level Hostettler,(2002).

[2] The occurrence of TMFs depends on the prevailing climate rather than a defined elevation, and they have lower temperatures and higher humidity relative to tropical lowland forests. TMFs can occur at elevations as low as 500 m above sea level, and as high as 2,000–3,000 m a.s.l. on large inland mountains. Forest structure is similarly variable, with lower-elevation TMF characterized by emergent trees up to 35 m tall, an absence of large buttress roots, two layers of canopy, and many non-vascular epiphytes Soh (2019).

meters elevation. Montane forest gives way to upper montane forest and mossy forest at around 1,800 meters elevation.

The mountain ranges of the State of Sarawak rise to over 1,500 meters and thus form the divide between Sarawak and Kalimantan. The State of the Sarawak mountains rises to more than 1,500 meters and thus forms a division between Sarawak and Kalimantan. The highest peaks in Sarawak are Murud at 2,424 meters and Mulu at 2,371 meters. Approximately 37% of the state is over 300 meters in altitude. In Sabah, at least 12 different types of vegetation are found throughout the state on the basis of elevation and soil type. Based on topography, Sabah is mountainous and Mount Kinabalu is a jagged granite massif and is the highest mountain (4,095 meters) in South-East Asia within Kinabalu Park. The park is also a UNESCO World Heritage site (Ahokumpu et al., 2014).

Tropical montane forests are broadly considered to be important for the provision of ecosystem services, especially water and ecosystems (Jeyanny et al., 2015). Climate change directly affects forests and their productivity through altered abiotic conditions, especially significant aspects such as net productivity (e.g. temperature and atmospheric CO2 concentrations) (Muttaleb et al., 2018). Tropical montane forests serve as a carbon sink due to their ability to store carbon in the soil, overland, forest floors, roots, and rough forest debris. This ecosystem is currently under pressure as a result of excessively anthropogenic developments (Peh et al., 2011). Tropical montane ecosystems have been changed by human use for hundreds of years (Aide et al., 2010). These forests are fragmented due to the altitudinal factor and are thus sensitive to changes in climate and land use. In addition, steep mountain slopes are vulnerable to erosion when forest canopies are eliminated. Global highland ecosystem problems include fragmentation of road construction, deforestation and growth related to tourism, temperate agriculture as well as townships and telecommunications facilities (Bruijnzeel et al., 2010).

1.2 Problem statement

Species are being planted throughout Southeast Asia as a source of future timber and to restore degraded lands. lack of knowledge on species-specific requirements for establishment increases the risk of failure by the improper selection of species and sites (Van Breugel et al., 2007). A detailed understanding of factors controlling seedling performance is required for the successful planting. Below-ground resource availability is hypothesize to have a significant effect on seedling performance of species when planted in selectively logged forests or in open, degraded areas (Vincent & Davies, 2003). Plantations can improve conditions for forest regeneration, the long-term impact on forest recovery depends on the species used, the management techniques, and the goals of the project (Aide et al., 2011). The effectiveness of enrichment planting depends on a wide variety of factors, including the circumstances of the site, the characteristics of the plants, the specific planting strategies and treatments used,

and social and economic factors (Vincent & Davies, 2003). It is therefore essential to find alternatives to improve the condition of the site on degraded lands and to encourage seedling development in the upland areas. The ability of mulch to strengthen soil composition, increase organic matter, and improve nutrient cycling patterns has been recognized (Tiquia et al. 2002). Many materials have been used as mulch, such as plastic film, crop residue, straw, paper pellets, gravel-sand, rock fragment, volcanic ash, poultry and live-stock litters, city rubbish, fresh grass, etc (Yang et al. 2006; Fang et al. 2007; Blanco-Garcı´a et al. 2008). Moreover, many studies were concentrated on agronomic systems (Adekalu et al. 2007) and landscape plants (Carlson 2000). In the restoration area, however little study has been done to evaluate the numerous mulching efficiencies. Therefore, an understanding of the appropriateness of mulching on degraded forest land is important to achieve numerous benefits in forest plantation.

1.3 Objectives

The general objective of this study is to assess the growth performance of Magnolia champaca in the degraded areas and the impact of three different types of mulching on growth performance of Magnolia champaca in a degraded areas.

The objectives of this study were the following:

a) To determine the growth performance and biomass of Magnolia champaca planted under different types of mulching at the degraded area.
b) To determine the effect of different types of mulching on soil properties at degraded area.

1.4 Hypothesis

Ho: There are no significant differences in Magnolia champaca under different types of mulching at the degraded area.
Hα: There are significant differences of Magnolia champaca under different types of mulching at the degraded area.

REFERENCES

Aris, N. A. Z., Zakaria, N., & Arumugam, N. (2017). Diversity of Lepidoptera at REACH Biod Centre, Cameron Highlands, Malaysia. Journal of Wildlife and Parks, 32, 41-55.

Adak, T., Singha, A., Kumar, K., Shukla, S. K., Singh, A., & Kumar Singh, V. (2014). Soil organic carbon, dehydrogenase activity, nutrient availability and leaf nutrient content as affected by organic and inorganic source of nutrient in mango orchard soil. Journal of Soil Science and Plant Nutrition, 14(2), 394-406.

Adekalu, K. O., Olorunfemi, I. A., & Osunbitan, J. A. (2007). Grass mulching effect on infiltration, surface runoff and soil loss of three agricultural soils in Nigeria. Bioresource Technology, 98(4), 912-917.

Agele, S. O., Olaore, J. B., & Akinbode, F. A. (2010). Effect of some mulch materials on soil physical properties, growth and yield of sunflower (Helianthus annuus L.). Advances in Environmental Biology, 4(3), 368-375.

Aris, N. A. Z., Zakaria, N., & Arumugam, N. (2017). Diversity of Lepidoptera at REACH Biod Centre, Cameron Highlands, Malaysia. Journal of Wildlife and Parks, 32, 41-55.

Ahirwar, S., Tiwari, M. K., Namwade, G., & Bhukya, S. (2019). Biodegradable Plastic Mulch for Water Conservation in Horticultural Crops. Int. J. Curr. Microbiol. App. Sci, 8(2), 1731-1737.

Aide, T. M., Ruiz-Jaen, M. C., & Grau, H. R. (2010). What is the state of tropical montane cloud forest restoration? Tropical Montane Cloud Forests Science for Conservation and Management. Cambridge: Cambridge University Press.

Amin, M., Jaleta, A., & Bersisa, H. (2018). Evaluation of Mulching Practice on the Survival and Subsequent Early Growth Performances of the Transplanted Coffee Seedlings. Universal Journal of Agricultural Research, 6(4), 119-126.

Aminuddin, B. Y., Ghulam, M. H., Abdullah, W. W., Zulkefli, M., & Salama, R. B. (2005). Sustainability of current agricultural practices in the Cameron Highlands, Malaysia. Water, Air, & Soil Pollution: Focus, 5(1-2), 89-101.

Ampoorter, E., De Schrijver, A., Van Nevel, L., Hermy, M., & Verheyen, K. (2012). Impact of mechanized harvesting on compaction of sandy and clayey

forest soils: results of a meta-analysis. Annals of Forest Science, 69(5), 533-542.

Angelova, V. R., Akova, V. I., Artinova, N. S., & Ivanov, K. I. (2013). The effect of organic amendments on soil chemical characteristics. Bulgarian Journal of Agricultural Science, 19(5), 958-971.

Ahokumpu, A. L., Auvinen, A. P., Pylvänäinen, M., & von Weissenberg, M. (2014). Fifth National Report to the Convention on Biological Diversity. Ministry of the Environment, Finland.

Ashton, P. M., Gamage, S., Gunatilleke, I. A., & Gunatilleke, C. V. (1997). Restoration of a Sri Lankan Rainforest: Using Caribbean Pine Pinus caribaea as a Nurse for Establishing Late-Successional Tree Species. The Journal of Applied Ecology, 34(4), 915. doi:10.2307/2405282

Atwell, B. J. (1993). Response of roots to mechanical impedance. Environmental and Experimental Botany, 33(1), 27-40.

Ambasht, R. S., & Ambasht, N. K. (Eds.). (2012). Modern trends in applied terrestrial ecology. Springer Science & Business Media. Banaras Hindu University Varanasi, India.

Armiyanti, M. A. K., Kadzimin, S., & Panjaitan, S. B. (2010). Full Length Research Paper Plant regeneration of Michelia champaca L., through somatic embryogenesis. African Journal of Biotechnology, 9(18), 2640-2647.

Aide, T. M., Zimmerman, J. K., Pascarella, J. B., Rivera, L., & Marcano-Vega, H. (2000). Forest regeneration in a chronosequence of tropical abandoned pastures: implications for restoration ecology. Restoration Ecology, 8(4), 328-338.

Bajoriene, K., Jodaugiene, D., Pupaliene, R., & Sinkeviciene, A. (2013). Effect of organic mulches on the content of organic carbon in the soil. Estonian Journal of Ecology, 62(2), 100.

Barajas-Guzmán, M. G., Campo, J., & Barradas, V. L. (2006). Soil water, nutrient availability and sapling survival under organic and polyethylene mulch in a seasonally dry tropical forest. Plant and Soil, 287(1-2), 347-357.

Bécel, C., Vercambre, G., & Pagès, L. (2012). Soil penetration resistance, a suitable soil property to account for variations in root elongation and branching. Plant and Soil, 353(1-2), 169-180.

Bengough, A. Glyn, et al. "Root elongation, water stress, and mechanical impedance: a review of limiting stresses and beneficial root tip traits." Journal of Experimental Botany 62.1 (2011): 59-68.

Benner, J., Vitousek, P. M., & Ostertag, R. (2010). Nutrient cycling and nutrient limitation in tropical montane cloud forests. Tropical Montane Cloud Forests Science for Conservation and Management. Cambridge: Cambridge University Press, 90-100.

Billeaud, L. A., & Zajicek, J. M. (1989). Influence of mulches on weed control, soil pH, soil nitrogen content, and growth of Ligustrum japonicum. Journal of Environmental Horticulture, 7(4), 155-157.

Blanco-García, A., Sáenz-Romero, C., Alvarado-Sosa, P., & Lindig-Cisneros, R. (2008). Native pine species performance in response to age at planting and mulching in a site affected by volcanic ash deposition. New Forests, 36(3), 299-305.

Bol, M., & Vroomen, D. (2008). The succession of pasture land towards original cloud forest in the pre-mountain area of Costa Rica (Bachelor's thesis, Van Hall Larenstein Institute, 2008) (pp. 8-49). Costa Rica: Van Hall Larenstein Institute.

Bruijnzeel, L., Kappelle, M., Mulligan, M., Scatena, F., Bruijnzeel, L. A., Scatena, F. N., & Hamilton, L. S. (2010). Tropical montane cloud forests: State of knowledge and sustainability perspectives in a changing world. Cambridge University Press, 691-740. doi:10.1017/cbo9780511778384.074

Bruno, L. (2019). Forestry Department Peninsular Malaysia Report 2018. Journal of Chemical Information and Modeling, 53(9), 1689–1699.

Bubb, P., May, I., Miles, L., Sayer, J. 2004 Cloud Forest Agenda. UNEP-WCMC, Cambridge, UK. Online at: http://www.unep-wcmc.org/resources/publications/UNEP_WCMC_bio_series/20.htm

Budiharta, S. (2016). The succession of pasture land towards original cloud forest in the pre-mountain area of Costa Rica (PhD's thesis, University of Queensland, 2016) (pp. 1-193). Australia: The University of Queensland.

Bai, S. H., Blumfield, T. J., & Reverchon, F. (2014). The impact of mulch type on soil organic carbon and nitrogen pools in a sloping site. Biology and Fertility of Soils, 50(1), 37-44.

Barthlott, W., Schmit-Neuerburg, V., Nieder, J., & Engwald, S. (2001). Diversity and abundance of vascular epiphytes: a comparison of secondary vegetation and primary montane rain forest in the Venezuelan Andes. Plant Ecology, 152(2), 145-156.

Bieganowski A., Ryżak M. (2011) Soil Texture: Measurement Methods. In: Gliński J., Horabik J., Lipiec J. (eds) Encyclopedia of Agrophysics. Encyclopedia of Earth Sciences Series. Springer, Dordrecht. https://doi.org/10.1007/978-90-481-3585-1_157

Bruijnzeel, L. A., Scatena, F. N., & Hamilton, L. S. (Eds.). (2011). Tropical montane cloud forests: science for conservation and management. Cambridge University Press.

Bhatt, B. P., Singha, L. B., Satapathy, K. K., Sharma, Y. P., & Bujarbaruah, K. M. (2010). Rehabilitation of shifting cultivation areas through agroforestry: a case study in Eastern Himalaya, India. Journal of Tropical Forest Science, 13-20.

Cambi, M., Certini, G., Neri, F., & Marchi, E. (2015). The impact of heavy traffic on forest soils: A review. Forest ecology and management, 338, 124-138.

Cereno, M. M. (2009). Assessment of Combined Hydroseeding and Coconet Reinforcement to Control Soil Erosion. In World Environmental and Water Resources Congress 2009: Great Rivers (pp. 1-10).

Carlson CR (2000) Mulching basics: are you covered? Grounds Maintenance 32(2):44–52

Candiani, G., Galetti, M., & Cardoso, V. J. M. (2004). Seed germination and removal of Michelia champaca L. (Magnoliaceae) in eucalypt stands: the influence of the aril. Revista Arvore, 28(3), 327-332.

Cambi, M., Hoshika, Y., Mariotti, B., Paoletti, E., Picchio, R., Venanzi, R., & Marchi, E. (2017). Compaction by a forest machine affects soil quality and Quercus robur L. seedling performance in an experimental field. Forest Ecology and Management, 384, 406-414.

Ceacero, C. J., Díaz-Hernández, J. L., del Campo, A. D., & Navarro-Cerrillo, R. M. (2012). Interactions between soil gravel content and neighboring vegetation control management in oak seedling establishment success in Mediterranean environments. Forest Ecology and Management, 271, 10-18.

Chuan, G. (2015). Improving Connectivity in the Central Forest Spine (CFS) Landscape - IC-CFS Project Inception Report(PIMS 4594), 77 [Scholarly project]. In UNDP. Retrieved 2015, from https://www.my.undp.org

Fransen, B. (2019, August 05). How to calculate CO2 sequestration. Retrieved November 18, 2020, from https://www.ecomatcher.com/how-to-calculate-co2-sequestration/

Coleman, J. S., McConnaughay, K. D., & Ackerly, D. D. (1994). Interpreting phenotypic variation in plants. Trends in Ecology & Evolution, 9(5), 187-191.

Crausbay, S. D., Martin, P. H., & Kelly, E. F. (2015). Tropical montane vegetation dynamics near the upper cloud belt strongly associated with a shifting ITCZ and fire. Journal of Ecology, 103(4), 891-903.

Chalker-Scott, L. (2007). Impact of mulches on landscape plants and the environment—a review. Journal of Environmental Horticulture, 25(4), 239-249.

Conlin, T. S. S., & Driessche, R. V. D. (2000). Response of soil CO2 and O2 concentrations to forest soil compaction at the long-term soil productivity sites in central British Columbia. Canadian Journal of Soil Science, 80(4), 625-632.

D'antonio, C. A. R. L. A., & Meyerson, L. A. (2002). Exotic plant species as problems and solutions in ecological restoration: a synthesis. Restoration Ecology, 10(4), 703-713.

Dahiya, R., & Malik, R. (2002). Trash and green mulch effects on soil N and P availability. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.497.3368&rep=rep1&type=pdf

Darmawan, D. (1997). Utilization of Coconut Coir Dust Mulch in the Tropics. Journal of Chemical Information and Modeling, 53(9), 1689–1699.

Davis, A. S., & Jacobs, D. F. (2005). Quantifying root system quality of nursery seedlings and relationship to outplanting performance. New Forests, 30(2-3), 295-311.

Dobson, M. (1995). Tree root systems. Arboriculture Research and Information Note-Department of the Environment (United Kingdom), (Vol. 130, Issue 95, pp. 1–6).

Dostálek, J., Weber, M., Matula, S., & Frantík, T. (2007). Forest stand restoration in the agricultural landscape: the effect of different methods of planting establishment. Ecological Engineering, 29(1), 77-86.

De los Ángeles García-Hernández, M., & Toledo-Aceves, T. (2020). Is there potential in elevational assisted migration for the endangered Magnolia vovidesii? Journal for Nature Conservation, 53, 125782.

Dalling, J. W., & John, R. (2008). Seed limitation and the coexistence of pioneer tree species. Tropical Forest Community Ecology, 242-253.

Eliasson, L., & Wästerlund, I. (2007). Effects of slash reinforcement of strip roads on rutting and soil compaction on a moist fine-grained soil. Forest Ecology and Management, 252(1-3), 118-123.

Eissa, N. M. H. (2002). Effect of some plasticulture and fertigation treatments on productivity and fruit quality of strawberry (Doctoral dissertation, Ph D Thesis, Faculty of Agriculture Zagazig University).

Fang, S., Xie, B., Liu, D., & Liu, J. (2011). Effects of mulching materials on nitrogen mineralization, nitrogen availability and poplar growth on degraded agricultural soil. New Forests, 41(2), 147-162.

Fang, S., Xie, B., & Liu, J. (2008). Soil nutrient availability, poplar growth and biomass production on degraded agricultural soil under fresh grass mulch. Forest Ecology and Management, 255(5-6), 1802-1809.

Fang, S., Xie, B., & Zhang, H. (2007). Nitrogen dynamics and mineralization in degraded agricultural soil mulched with fresh grass. Plant and soil, 300(1-2), 269-280.

Feeley, K. J., Hurtado, J., Saatchi, S., Silman, M. R., & Clark, D. B. (2013). Compositional shifts in C osta R ican forests due to climate-driven species migrations. Global Change Biology, 19(11), 3472-3480.

Ferrini, F., Fini, A., Frangi, P., & Amoroso, G. (2008). Mulching of ornamental trees: effects on growth and physiology. Arboriculture and Urban Forestry, 34(3), 157.

Fini, A., & Ferrini, F. (2011). Effects of mulching with compost on growth and physiology of Acer campestre L. and Carpinus betulus L. Advances in Horticultural Science, 232-238.

Fini, A., Degl'Innocenti, C., & Ferrini, F. (2016). Effect of mulching with compost on growth and physiology of Ulmus 'FL634'planted in an urban park. Arboriculture and Urban Forestry, 42, 192-200.

Fite, K., Thomas Smiley, E., McIntyre, J., & Wells, C. E. (2011). Evaluation of a soil decompaction and amendment process for urban trees. Arboriculture and Urban Forestry, 37(6), 293.

Foster, P. (2001). The potential negative impacts of global climate change on tropical montane cloud forests. Earth-Science Reviews, 55(1-2), 73-106.

Fründ, H. C., & Averdiek, A. (2016). Soil aeration and soil water tension in skidding trails during three years after trafficking. Forest Ecology and Management, 380, 224-231.

Gao, Y., Li, Y., Wang, Y., Wu, B., Ke, J., Niu, J., & Guo, L. (2020). Effect of different film color mulching on dry matter and grain yield of oil flax in dry-land. Oil Crop Science, 5(2), 17-22. doi:10.1016/j.ocsci.2020.04.003

Gasim, M. B., Ismail Sahid, E. T., Pereira, J. J., Mokhtar, M., & Abdullah, M. P. (2009). Integrated water resource management and pollution sources in Cameron Highlands, Pahang, Malaysia. American-Eurasian J Agric Environ Sci, 5, 725-732.

Gu, C., Liu, Y., Mohamed, I., Zhang, R., Wang, X., Nie, X., & Li, Z. (2016). Dynamic changes of soil surface organic carbon under different mulching practices in citrus orchards on sloping land. PLoS One, 11(12), e0168384.

Guo, T., Wang, Q., Li, D., & Zhuang, J. (2010). Effect of surface stone cover on sediment and solute transport on the slope of fallow land in the semi-arid loess region of northwestern China. Journal of Soils and Sediments, 10(6), 1200-1208.

Helaly, A. A., Goda, Y., El-Rehim, A. A. S., Mohamed, A. A., & El-Zeiny, O. A. H. (2017). Effect of Polyethylene Mulching Type on the Growth, Yield and Fruits Quality of Physalis Pubescens. Advances in Plants & Agriculture Research, 6(5). https://doi:10.15406/apar.2017.06.00229

Han, X., Li, Y., Wang, L., Liu, S., & Zhang, J. (2015). Effect of Tree-Row Mulching On Soil Characteristics As Well As Growth and Development of Pear Trees. Acta Horticulturae, (1094), 299-306. doi:10.17660/actahortic.2015.1094.38

Haque, M. A., Jahiruddin, M., & Clarke, D. (2018). Effect of plastic mulch on crop yield and land degradation in south coastal saline soils of Bangladesh. International Soil and Water Conservation Research, 6(4), 317-324.

Harris, J. B. C., Dwi Putra, D., Gregory, S. D., Brook, B. W., Prawiradilaga, D. M., Sodhi, N. S., ... & Fordham, D. A. (2014). Rapid deforestation threatens mid-elevational endemic birds but climate change is most important at higher elevations. Diversity and Distributions, 20(7), 773-785.

Helmer, E. H., Gerson, E. A., Baggett, L. S., Bird, B. J., Ruzycki, T. S., & Voggesser, S. M. (2019). Neotropical cloud forests and páramo to contract and dry from declines in cloud immersion and frost. PloS One, 14(4), e0213155.

Hietz, P., Winkler, M., Scheffknecht, S., & Hülber, K. (2012). Germination of epiphytic bromeliads in forests and coffee plantations: microclimate and substrate effects. Biotropica, 44(2), 197-204.

Holl, K. D. (1999). Factors Limiting Tropical Rain Forest Regeneration in Abandoned Pasture: Seed Rain, Seed Germination, Microclimate, and Soil 1. Biotropica, 31(2), 229-242.

Holl, K. D. (2002). Tropical moist forest restoration. In 'Handbook of ecological restoration', Vol. II.(Eds AJ Davy and M. Perrow.) pp. 539–558.

Huang, P., Xun, M., Yue, S., Zhang, W., Fan, W., & Yang, H. (2018, August). Effect of rice straw mat and other mulching on apple root architecture and soil environment in root-zone. In XXX International Horticultural Congress IHC2018: International Symposium on Cultivars, Rootstocks and Management Systems of 1281 (pp. 163-170).

Hostettler, S. (2002). Tropical montane cloud forests: a challenge for conservation. Bois et Forêts des tropiques, 274(4), 19-31.

Iiles, J. K. (1999). Effect of organic and mineral mulches in soil properties and growth of Fairview flame red maple trees. J. Arbori., 25(3), 163-167.

Iatrou, M., Papadopoulos, A., Papadopoulos, F., Dichala, O., Psoma, P., & Bountla, A. (2014). Determination of soil available phosphorus using the Olsen and Mehlich 3 methods for Greek soils having variable amounts of calcium carbonate. Communications in Soil Science and Plant Analysis, 45(16), 2207-2214.

Jeyanny, V., Wan Rasidah, K., & Husni, M. (2015). The unusual suspect in carbon storage and its importance to soil security. Proceedings of the Soil Science Conference of Malaysia, 1-5.

Jordán, A., Zavala, L. M., & Gil, J. (2010). Effects of mulching on soil physical properties and runoff under semi-arid conditions in southern Spain. Catena, 81(1), 77-85.

Jourgholami, M. (2018). Effects of soil compaction on growth variables in Cappadocian maple (Acer cappadocicum) seedlings. Journal of Forestry Research, 29(3), 601-610.

Jourgholami, M., Fathi, K., & Labelle, E. R. (2020). Effects of litter and straw mulch amendments on compacted soil properties and Caucasian alder (Alnus subcordata) growth. New Forests, 51(2), 349-365.

Jourgholami, M., Nasirian, A., & Labelle, E. R. (2018). Ecological restoration of compacted soil following the application of different leaf litter mulches on the skid trail over a five-year period. Sustainability, 10(7), 2148.

Kader, M. A., Senge, M., Mojid, M. A., & Ito, K. (2017). Recent advances in mulching materials and methods for modifying soil environment. Soil and Tillage Research, 168, 155-166.

Kala, D. R., Rosenani, A. B., Fauziah, C. I., & Thohirah, L. A. (2009). Composting oil palm wastes and sewage sludge for use in potting media of ornamental plants. Malaysian Journal of Soil Science, 13(1), 77-91.

Kanehiro Kitayama • Noreen Majalap-LeeShin-ichiro Aiba. (2000). Argentina: two variants of a single design. Politica Internazionale, 2(2), 26–35.

Kasperbauer, M. J. (1987). Far-red light reflection from green leaves and effects on phytochrome-mediated assimilate partitioning under field conditions. Plant Physiology, 85(2), 350-354.

Kettler, T. A., Doran, J. W., & Gilbert, T. L. (2001). Simplified method for soil particle-size determination to accompany soil-quality analyses. Soil Science Society of America Journal, 65(3), 849-852.

Kurilenko, L.N., Kostyreva, T.G. Determination of quantities of sodium and potassium taking into account their mutual influence in glass and zeolites using the method of flame atomic emission spectrometry. Glass Phys Chem 42, 266–269 (2016). https://doi.org/10.1134/S1087659616030068

Khan, A. R., Singh, S. S., Anand, P. S. B., Nanda, P., & Chandra, D. (2002). Effect of organic mulching on physico-chemical properties of soil (No. IC/IR--2002/15). Abdus Salam International Centre for Theoretical Physics.

Kumaran, S., Perumal, B., Davison, G., Ainuddin, A. N., Lee, M. S., & Bruijnzeel, L. A. (2011). Tropical Montane Cloud Forests: Tropical montane cloud forests in Malaysia: current state of knowledge. Cambridge University Press.

Kosterna, E. (2014). The effect of covering and mulching on the soil temperature, growth and yield of tomato. Folia Horticulturae, 26(2), 91-101.

Kueh, R. J. H., Mang, N. G., Huat, O. K., Sait, M., Sam, S., Empin, G. B., & Rajanoran, T. (2017). Tree diversity at Payeh Maga Montane Forest, Sarawak, Borneo. Journal of Tropical Biology & Conservation (JTBC).

Kumar, V., Sharma, J. C., Kumar, M., & Singh, S. K. (2017). Soil and Plant Nutrient Status as Modified by Different Types of Mulching in Cauliflower. Current Journal of Applied Science and Technology, 1-8.

Kumaran, S., Perumal, B., Davison, G., Ainuddin, A. N., Lee, M. S., Bruijnzeel, L. A., & Hamilton, L. S. (2010). Tropical montane cloud forests in Malaysia: Current state of knowledge. Cambridge University Press.

Kundu, S. R. (2009). A synopsis on distribution and endemism of Magnoliaceae sl in Indian Subcontinent. Thaiszia Journal of Botany, 19, 47-60.

Labelle, E. R., & Kammermeier, M. (2019). Above-and belowground growth response of Picea abies seedlings exposed to varying levels of soil relative bulk density. European Journal of Forest Research, 138(4), 705-722.

Lai, P., & Wong, B. (2005). Effects of tree guards and weed mats on the establishment of native tree seedlings: implications for forest restoration in Hong Kong, China. Restoration Ecology, 13(1), 138-143.

Lambers, H., Chapin III, F. S., & Pons, T. L. (2008). Plant physiological ecology. Springer Science & Business Media.

Li, S. X., Wang, Z. H., Li, S. Q., Gao, Y. J., & Tian, X. H. (2013). Effect of plastic sheet mulch, wheat straw mulch, and maize growth on water loss by evaporation in dryland areas of China. Agricultural Water Management, 116, 39-49.

Lucheta, A. R., & Lambais, M. R. (2012). Sulfur in agriculture. Revista Brasileira de Ciência do Solo, 36(5), 1369-1379.

Lynch, J., Marschner, P., & Rengel, Z. (2012). Effect of internal and external factors on root growth and development. In Marschner's Mineral Nutrition of Higher Plants (pp. 331-346). Academic Press.

Lynch J.P., Brown K.M. (2008) Root strategies for phosphorus acquisition. In: White P.J., Hammond J.P. (eds) The Ecophysiology of Plant-Phosphorus Interactions. Plant Ecophysiology, vol 7. Springer, Dordrecht. https://doi.org/10.1007/978-1-4020-8435-5_5

Lynch, J. P., & Brown, K. M. (2001). Topsoil foraging–an architectural adaptation of plants to low phosphorus availability. Plant and Soil, 237(2), 225-237.

Mandang, T., Sinambela, R., & Pandianuraga, N. (2018). Physical and mechanical characteristics of oil palm leaf and fruits bunch stalks for bio-mulching. Earth and Environmental Science, 1-15. https://doi:10.1088/1755-1315/196/1/012015

Mansourian, S., & Vallauri, D. (Eds.). (2005). Forest restoration in landscapes: beyond planting trees. Springer Science & Business Media.

Marichamy, M., Thomas, A., Jayabharathi, J., Thomas, A., & Kanthaswamy, V. (2016). Effect of Different Mulches on Weed Characters, Chlorophyll and Vitamin-C Content of Chilli (Capsicum annuum L) Hybrid Sierra. Advances in Life Sciences, 5(4), 1-476.

McCarthy, N., Mc Carthy, C., & Rathaille, M. O. (2007). Mulch Mats: Their Potential in Establishing Forest and Other Tree Crops. National Council for Forest Research and Development, Dublin, Ireland.

McIntyre, B. D., Speijer, P. R., Riha, S. J., & Kizito, F. (2000). Effects of mulching on biomass, nutrients, and soil water in banana inoculated with nematodes. Agronomy Journal, 92(6), 1081-1085.

Moffat, D. and. (2008). Woodland Establishment on Landfill Sites - Ten Years of Research. 75.

Monre. (2016). National Policy On Biological Diversity 2016-2025. Ministry Of Natural Resouraces and Environment, Malaysia, 116.

Moody, P. W., & Phan, T. C. (2008). Soil Constraints and Management Package (SCAMP): guidelines for sustainable management of tropical upland soils. Australian Centre for International Agricultural Research (ACIAR).

Morin, X., Fahse, L., Jactel, H., Scherer-Lorenzen, M., García-Valdés, R., & Bugmann, H. (2018). Long-term response of forest productivity to

climate change is mostly driven by change in tree species composition. Scientific Reports, 8(1), 1-12.

Muttaleb, A. (2018). The Effect of Three Different Mulches on Weed Presence, Soil Characteristics, and Zinnia Growth". Murray State Theses and Dissertations. 77.

Muhammad, R., Sahibin, A. R., Wan, M., Tukimat, L., & Zulfahmi, A. R. (2015). CA-Markov for predicting land use changes in tropical catchment area: a case study in Cameron Highland, Malaysia. Journal of Applied Sciences, 15(4), 689-695.

Nepstad, D. C., Uhl, C., Pereira, C. A., & Da Silva, J. M. C. (1996). A comparative study of tree establishment in abandoned pasture and mature forest of eastern Amazonia. Oikos, 25-39.

Ni, X., Song, W., Zhang, H., Yang, X., & Wang, L. (2016). Effects of mulching on soil properties and growth of tea olive (Osmanthus fragrans). Plos One, 11(8), e0158228.

Nooteboom, H. P., & CHaLerMGLin, P. (2009). The Magnoliaceae of Thailand. Thai Forest Bulletin (Botany), (37), 111-138.

Niiyama, K., Kajimoto, T., Matsuura, Y., Yamashita, T., Matsuo, N., Yashiro, Y., Noor, N. (2010). Estimation of root biomass based on excavation of individual root systems in a primary dipterocarp forest in Pasoh Forest Reserve, Peninsular Malaysia. Journal of Tropical Ecology, 26(3), 271-284. Retrieved April 19, 2021, from http://www.jstor.org/stable/40665234

Ogundare, S. K., Babatunde, I. J., & Etukudo, O. O. (2015). Response of tomato variety (Roma F) yield to different mulch materials and staking in Kabba, Kogi State, Nigeria. J. of Agric. Studies, 3, 61-70.

Ojanen, P., Mäkiranta, P., Penttilä, T., & Minkkinen, K. (2017). Do logging residue piles trigger extra decomposition of soil organic matter? Forest Ecology and Management, 405, 367-380.

Ong, C. K., & Huxley, P. A. (Eds.). (1996). Tree-crop interactions: a physiological approach (Vol. 386). Wallingford, UK: CAB International.

Orwa, C., Mutua, A., Kindt, R., Jamnadass, R., & Anthony, S. (2009). Agroforestree Database: a tree reference and selection guide version 4.0. World Agroforestry Centre, Kenya, 15.

Nooteboom, H. P., & Chalermglin, P. (2000). A new species of Magnolia (Magnoliaceae) from Thailand. Blumea, 45(1), 245-247.

Peh, K. S. H., Soh, M. C., Sodhi, N. S., Laurance, W. F., Ong, D. J., & Clements, R. (2011). Up in the clouds: is sustainable use of tropical montane cloud forests possible in Malaysia? Bioscience, 61(1), 27-38. https://doi:10.1525/bio.2011.61.1.8

Perry, T. O. (1989). Tree roots: facts and fallacies. Arnoldia, 49(4), 3-29.

Picchio, R., Tavankar, F., Nikooy, M., Pignatti, G., Venanzi, R., & Lo Monaco, A. (2019). Morphology, growth and architecture response of beech (Fagus orientalis Lipsky) and maple tree (Acer velutinum Boiss.) seedlings to soil compaction stress caused by mechanized logging operations. Forests, 10(9), 771.

Pilla, R. S., Kitska, D. J., & Loader, C. (2005). Statistical analysis of modified complete randomized designs: applications to chemo-orientation studies. Journal of experimental biology, 208(7), 1267-1276. https://doi:10.1242/jeb.01523

Qian, X., Gu, J., Pan, H. J., Zhang, K. Y., Sun, W., Wang, X. J., & Gao, H. (2015). Effects of living mulches on the soil nutrient contents, enzyme activities, and bacterial community diversities of apple orchard soils. European Journal of Soil Biology, 70, 23-30.

Qu, B., Liu, Y., Sun, X., Li, S., Wang, X., Xiong, K., & Zhang, H. (2019). Effect of various mulches on soil physico—Chemical properties and tree growth (Sophora japonica) in urban tree pits. PloS One, 14(2), e0210777.

Yetti, H., Arifin, A., Mohd, N. M., Hazandy, A. H., Shamshuddin, J., Nik, M. M., & Khairulmazmi, A. (2011). Assessing forest plantation productivity of exotic and indigenous species on degraded secondary forests. American Journal of Agricultural and Biological Sciences, 6(2), 201-208.

Radam, A., Islam, G. M. N., Ng, K. Y., Arshad, F. M., & Alias, E. F. (2015). Impact of producing tomatoes under Malaysia-GAP certification on farming practices, Cameron Highlands. Food and Agriculture Organization of the United Nations (FAO), 1-24.

Roozitalab, M. H. H. Serghini, A. Keshavarz, V. Eser, E. de-P. (2013). Working Paper Sustainable Agricultural Development of Highlands in Central , West Asia and North Africa Elements of a Research Strategy and Priori ti es. International Center for Agriculture Research in the Dry Areas, 52.

Rahbek, C. (1997). The relationship among area, elevation, and regional species richness in neotropical birds. The American Naturalist, 149(5), 875-902.

Raich, J. W., Russell, A. E., Kitayama, K., Parton, W. J., & Vitousek, P. M. (2006). Temperature influences carbon accumulation in moist tropical forests. Ecology, 87(1), 76-87.

Razali, A., Ismail, S. N. S., Awang, S., Praveena, S. M., & Abidin, E. Z. (2018). Land use change in highland area and its impact on river water quality: a review of case studies in Malaysia. Ecological Processes, 7(1), 19.

Suratman, M. N., Hamid, N. H. A., Sabri, M. D. M., Kusin, M., & Yamani, S. A. K. (2015). Changes in tree species distribution along altitudinal gradients of montane forests in Malaysia. In Climate Change Impacts on High-Altitude Ecosystems (pp. 491-522). Springer, Cham.

Saadati, N., Abdullah, M. P., Zakaria, Z., Rezayi, M., & Hosseinizare, N. (2012). Distribution and fate of HCH isomers and DDT metabolites in a tropical environment–case study Cameron Highlands–Malaysia. Chemistry Central Journal, 6(1), 130.

Salehi, A., Ghorbanzadeh, N., & Kahneh, E. (2013). Earthworm biomass and abundance, soil chemical and physical properties under different poplar plantations in the north of Iran. Journal of Forest Science, 59(6), 223-229.

Saroa, G. S., & Lal, R. (2004). Mulching effects on phosphorus and sulfur concentrations in a Miamian soil in central Ohio, USA. Land degradation & Development, 15(4), 351-365.

Sax, D. F., & Gaines, S. D. (2008). Species invasions and extinction: the future of native biodiversity on islands. Proceedings of the National Academy of Sciences, 105(Supplement 1), 11490-11497.

Sato, J. H., Figueiredo, C. C. D., Marchão, R. L., Madari, B. E., Benedito, L. E. C., Busato, J. G., & Souza, D. M. D. (2014). Methods of soil organic carbon determination in Brazilian savannah soils. Scientia Agricola, 71(4), 302-308. https://doi.org/10.1590/0103-9016-2013-0306

Schneider, F., Amelung, W. & Don, A. Origin of carbon in agricultural soil profiles deduced from depth gradients of C:N ratios, carbon fractions, δ13C and δ15N values. Plant Soil 460, 123–148 (2021). https://doi.org/10.1007/s11104-020-04769-w

Scharenbroch, B. C. (2009). A meta-analysis of studies published in Arboriculture & Urban Forestry relating to organic materials and impacts on soil, tree, and environmental properties. Journal of Arboriculture, 35(5), 221.

Schenk, H. J., & Jackson, R. B. (2002). Rooting depths, lateral root spreads and below-ground/above-ground allometries of plants in water-limited ecosystems. Journal of Ecology, 480-494.

Schlaepfer, M. A., Sax, D. F., & Olden, J. D. (2011). The potential conservation value of non-native species. Conservation Biology, 25(3), 428-437.

Sinkevičienė, A., Jodaugienė, D., Pupalienė, R., & Urbonienė, M. (2009). The influence of organic mulches on soil properties and crop yield. Agronomy Research, 7(1), 485-491.

Siwek, P., Kalisz, A., & Domagala-Swiatkiewicz, I. (2015). The influence of degradable polymer mulches on soil properties and cucumber yield, 108-123.

Soh, M. C., Mitchell, N. J., Ridley, A. R., Butler, C. W., Puan, C. L., & Peh, K. S. (2019). Impacts of Habitat Degradation on Tropical Montane Biodiversity and Ecosystem Services: A Systematic Map for Identifying Future Research Priorities. Frontiers in Forests and Global Change, 2. https://doi:10.3389/ffgc.2019.00083

Sonter, L. J., Johnson, J. A., Nicholson, C. C., Richardson, L. L., Watson, K. B., & Ricketts, T. H. (2017). Multi-site interactions: Understanding the offsite impacts of land use change on the use and supply of ecosystem services. Ecosystem Services, 23, 158-164.

Spracklen, D. V., & Righelato, R. (2014). Tropical montane forests are a larger than expected global carbon store. Biogeosciences, 11(10), 2741-2754.

Steinmetz, R., Chutipong, W., Seuaturien, N., & Chirngsaard, E. (2008). Community Structure of Large Mammals in Tropical Montane and Lowland Forest in the Tenasserim-Dawna Mountains, Thailand. Biotropica, 40(3), 344-353.

Szatanik-Kloc, A., Horn, R., Lipiec, J., Siczek, A., & Boguta, P. (2019). Initial growth and root surface properties of dicotyledonous plants in structurally intact field soil and compacted headland soil. Soil and Tillage Research, 195, 104387.

Shukla, A., Panchal, H., Mishra, M., Patel, P. R., Srivastava, H. S., Patel, P., & Shukla, A. K. (2014). Soil moisture estimation using gravimetric

technique and FDR probe technique: a comparative analysis. Am Int J Res Formal, Appl Nat Sci, 8, 89-92?

Sukewijaya, I. M., Mahendra, M. S., Rai, I. N., & Temaja, I. G. R. M (2016). Morphological Characters and Genetic Variability of Champaca in Bali. International Journal of Biosciences and Biotechnology, 4(1).

Spracklen, D. V., & Righelato, R. (2016). Carbon storage and sequestration of re-growing montane forests in southern Ecuador. Forest Ecology and Management, 364, 139-144.

Thang, H. C., & Chappell, N. A. (2005). Minimising the hydrological impact of forest harvesting in Malaysia's rainforests. Forests, Water and People in the Humid Tropics, 852-865. https://doi:10.1017/cbo9780511535666.045

Thankamani, C. K., Kandiannan, K., Hamza, S., & Saji, K. V. (2016). Effect of mulches on weed suppression and yield of ginger (Zingiber officinale Roscoe). Scientia Horticulturae, 207, 125-130.

Tsai, C. F., Lee, Y. F., Chen, Y. H., Chen, W. M., & Kuo, Y. M. (2015). Species turnover in tropical montane forest avifauna links to climatic correlates. Global Ecology and Conservation, 3, 541-552.

Tiquia, S. M., Lloyd, J., Herms, D. A., Hoitink, H. A., & Michel Jr, F. C. (2002). Effects of mulching and fertilization on soil nutrients, microbial activity and rhizosphere bacterial community structure determined by analysis of TRFLPs of PCR-amplified 16S rRNA genes. Applied soil ecology, 21(1), 31-48.

The Authority on Travel & Tourism. (n.d.). Retrieved November 18, 2020, from https://wttc.org/

Van Breugel, M., Bongers, F., & Martínez-Ramos, M. (2007). Species dynamics during early secondary forest succession: recruitment, mortality and species turnover. Biotropica, 39(5), 610-619.

Vozzo, J. A. (2002). Tropical tree seed manual (No. 721). US Department of Agriculture, Forest Service.

Viera, M., & Rodríguez-Soalleiro, R. (2019). A Complete Assessment of Carbon Stocks in Above and Belowground Biomass Components of a Hybrid Eucalyptus Plantation in Southern Brazil. Forests, 10(7), 536.

Vincent, A., & Davies, S. J. (2003). Effects of nutrient addition, mulching and planting-hole size on early performance of Dryobalanops aromatica and

Shorea parvifolia planted in secondary forest in Sarawak, Malaysia. Forest Ecology and Management, 180(1-3), 261-271.

Wang, H., Wang, C., Zhao, X., & Wang, F. (2015). Mulching increases water-use efficiency of peach production on the rainfed semiarid Loess Plateau of China. Agricultural Water Management, 154, 20-28.

Wang, Y. P., Li, X. G., Fu, T., Wang, L., Turner, N. C., Siddique, K. H., & Li, F. M. (2016). Multi-site assessment of the effects of plastic-film mulch on the soil organic carbon balance in semiarid areas of China. Agricultural and Forest Meteorology, 228, 42-51.

Weng, T. K., & Mokhtar, M. B. (2011). Emerging issues towards sustainable river basin management in Cameron Highlands, Malaysia. Environment and Natural Resources Journal, 9(2), 58-68.

Watson, G. W., Hewitt, A. M., Custic, M., & Lo, M. (2014). The Management of Tree Root Systems in Urban and Suburban Settings: A Review of Soil Influence on Root Growth. Arboriculture & Urban Forestry, 40(4).

Weebers, R. C., & Idris, H. (2016). Decisions made on the Development of the Hill Station of Cameron Highlands from 1884 till present day. Journal of Surveying, Construction and Property, 7(1), 1-11.

Williams, J. P., Khan, M. U., & Lem, N. W. (Eds.). (2013). Physiology, biochemistry and molecular biology of plant lipids. Springer Science & Business Media.

Wulffraat, S., & Morrison, J. (2013). Measuring biological indicators for status assessment of the heart of Borneo. Environmental conservation, 40(3), 277-286.

Yang, Y. M., Liu, X. J., Li, W. Q., & Li, C. Z. (2006). Effect of different mulch materials on winter wheat production in desalinized soil in Heilonggang region of North China. Journal of Zhejiang University Science B, 7(11), 858-867.

Zaini, H., Che, Y. A., Ahmad, S., & Ab Khalik, W. (2014). Quantifying Soil Erosion and Deposition Rates in Tea Plantation Area, Cameron Highlands, Malaysia Using 137 Cs. Malaysian Journal of Analytical Sciences, 18(1), 94-106.

Zhao, H., Wang, R. Y., Ma, B. L., Xiong, Y. C., Qiang, S. C., Wang, C. L., ... & Li, F. M. (2014). Ridge-furrow with full plastic film mulching improves water use efficiency and tuber yields of potato in a semiarid rainfed ecosystem. Field Crops Research, 161, 137-148.

Zhang, P., Wei, T., Cai, T., Ali, S., Han, Q., Ren, X., & Jia, Z. (2017). Plastic-film mulching for enhanced water-use efficiency and economic returns from maize fields in semiarid China. Frontiers in Plant Science, 8, 512.

Xiong, J., Tian, Y., Wang, J., Liu, W., & Chen, Q. (2017). Comparison of coconut coir, rockwool, and peat cultivations for tomato production: nutrient balance, plant growth and fruit quality. Frontiers in Plant Science, 8, 1327.

BIODATA OF STUDENT

Wahidullah Rahmani was born on 14th June 1989, in Kabul Province of Afghanistan. He is a child of Habibullah Rahmani and Hanifa Zewari. He attended both primary and secondary school in Amir Ali Shir Nawaei. He proceeded to Herat University where he obtained Bachelor degree in Horticulture under faculty of Agriculture. Upon completion of Bachelor degree, he did not hesitate to enroll into a Master program in the field Forest Management and Ecosystem Sciences in the Faculty of Forestry and Environment, Universiti Putra Malaysia in 2018.

PUBLICATION

Wahidullah Rahmani, Mohd Nazre Salleh, Mohd Zaki Hamzah, Aminu Abdu, Mohamad Fakhri Ishak, Wan Rasidah Wan Abd Khadir, Mohd Ridza Awang, Zahari Ibrahim, Ahmad Fadzil Abd Majid, Mohd Shahrir Azrin Salleh, Azhar Anuar, Mohamad Azani Bin Alias, "Effect of Different Types of Mulching on Soil Properties and Tree Growth of Magnolia champaca Planted at the Montane Rainforest in Cameron Highlands, Pahang, Malaysia", International Journal of Forestry Research, vol. 2021, Article ID 5517238, 11 pages, 2021. https://doi.org/10.1155/2021/55