TREE SPECIES INFLUENCE ON STREET MICROCLIMATIC CONDITIONS

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By

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DEDICATION

Firstly, this thesis is dedicated to God, my provider of strength and wisdom. His never ending love and grace has helped me these two semesters of my final year project journey.

For my beloved parents, Tan Tack Nee and Tan Soo Chin, showed me great love and support. Thank you for being constant cheerleaders throughout this journey. I would like to offer my gratitude to my siblings, friends, and course mates for giving much encouragement and help. They had cheered me on when I felt discouraged. Thank you for believing in me.

May God bless all of us.

ABSTRACT

Urbanization and urban heat island (UHI) have become more intense and caused many heat-related diseases to urban population. Trees serve as an asset to improve urban street microclimate conditions. However, physical tree characteristics such as canopy shape, size, leaves, branching characteristics and arrangement varies among different tree species, thus may influence the street microclimate. Therefore, the objectives of this study were to evaluate microclimate benefits of urban street trees and effects of different trees with different leaf and canopy characteristics on street microclimatic conditions. Five different tree species with different canopy and leaf characteristics were studied in early 2019. Microclimatic measurements such as air temperature, solar radiation, wind speed, and relative humidity were measured on pedestrian walkways below tree canopies and in open areas during solar noon time, 12pm – 2 pm on seven hot and sunny days. Trees with different Plant Area Index (PAI) were determined using digital photography. Street with trees provided significantly greater microclimatic benefits compared to the open area and microclimate benefits were greater with increasing tree PAI index. *Samanea saman* showed the greatest microclimate benefits by greatest reduction in air temperature by 1.4ºC and had the highest relative humidity with 53.7% while *Roystonea regia* provided the least microclimate benefits as it had the highest rate of air temperature with 35.1 ºC, solar radiation with 501.6 W/m^2. However, there were no significant differences of different five tree species on wind speed measurement. Present study indicated that different tree species with different physical characteristics such as canopy density and shape, tree height, branching and leaves arrangement affects the street microclimatic conditions. This study assists urban planners in proper selection of street tree species according to their improvement of microclimatic conditions.

ABSTRAK

Pembandaran dan pulau panas bandar (UHI) berlaku semakin kerap dan menyebabkan pelbagai penyakit yang berkaitan dengan haba kepada penduduk bandar. Keadaan mikro-iklim jalan adalah dipengaruhi daripada pokok jalan dengan ciri-ciri fizikal yang berbeza. Ciri-ciri dan susunan kanopi, daun, dahan adalah berbeza antara species pokok yang berlainan. Objektif kajian ini adalah untuk menguji manfaat mikro-iklim pokok jalan bandar dan pengaruh keadaan mikro-iklim jalan bandar daripada pokok-pokok dengan ciri daun dan kanopi yang berlainan. Lima species pokok yang berbeza dengan ciri-ciri kanopi dan daun yang berbeza telah dikaji pada awal tahun 2019. Pengukuran mikro-iklim seperti suhu udara, sinaran matahari, kelajuan angin dan kelembapan telah dijalankan di laluan pejalan kaki bawah pokok dan tempat terbuka, pada waktu tengahari 12pm – 2pm untuk tujuh hari yang panas dan cerah. Pokok dengan Plant Area Index (PAI) yang berlainan telah ditentukan dengan menggunakan fotografi digital. Jalan yang mempunyai pokok menyumbangkan manfaat mikro-iklim yang lebih besar berbanding dengan kawasan terbuka. Manfaat mikro-iklim lebih besar mengikuti PAI yang meningkat. *Samanea saman* telah menunjukkan manfaat mikro-iklim terbesar dengan pengurangan terbesar dalam suhu udara dengan 1.4ºC dan mempunyai kelembapan tertinggi dengan 53.7% manakala *Roystonea regia* memberikan paling kurang manfaat mikro-iklim di mana R. *regia* mempunyai suhu udara tertinggi dengan 35.1ºC, sinaran matahari dengan 501.6 W/m^2. Walau bagaimanapun, tidak terdapat perbezaan yang ketara pada pengukuran kelajuan angina antara lima species pokok. Faktor-faktor lain seperti ciri jalan, pergerakan kenderaan perlu dipertimbangkan untuk memilih spesies pokok yang sesuai untuk kesan teduhan dan penyejukan. Kajian ini telah menunjukkan bahawa spesies pokok yang berlainan dengan ciri-ciri fizikal yang berbeza seperti ketumpatan dan bentuk kanopi, ketinggian pokok, susunan daun dan dahan boleh mempengaruhi keadaan mikro-iklim jalan raya. Kajian ini membantu perancang bandar untuk memilih spesies pokok jalan yang berpotensi untuk memperbaiki keadaan mikro-iklim jalan raya.

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APPROVAL SHEET

I certify that this research project report entitled “Tree Species Influence on Street Microclimatic Conditions” by Tan Xiu Han has been examined and approved as a partial fulfilment of the requirements for the Degree of Bachelor of Forestry Science in the Faculty of Forestry, Universiti Putra Malaysia.

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CHAPTER ONE

INTRODUCTION

1.1 General Background

Rapid urbanization requires more attention and concern as related heat waves caused by massive urbanization has become more frequent, which also caused effects of Urban Heat Island (UHI) (World Health Organization, 2019). UHI is a phenomenon which urban regions experience warmer temperatures compared to the rural, undeveloped surroundings (Roth, 2013). UHI increased thermal discomfort towards urban communities, pollution levels and heat-related diseases.

The primary reason of heat island in cities was due to building structures, roads and other surfaces absorbing solar radiation during daytime (Wong & Yu, 2005). This phenomenon is also caused by the absorbing solar radiation from dark, dense surfaces and the three-dimensional form of buildings; reduced vegetation abundance; and the addition of waste heat from anthropogenic sources (Larsen, 2015). One way of reducing UHI phenomenon is through urban greenery or vegetation cover which were studied and proven by few research studies (Dimoudi & Nikolopoulou, 2003; Armson et al., 2012; Zhao et al., 2018).

Studies on green areas role in controlling urban climate have been explored for many years. Wong & Yu (2005) had summarized the three categories of UHI

studies, which are meteorological data and satellite images; in-depth field measurement; and numerical calculations. Green areas also provided other benefits such as reducing energy demand and source reduction of water and air pollution.

Governmental sectors and urban planners need to implement and design more efficient operative solutions for cooler cities (Aflaki et al., 2017). To maximize the potential of green areas or vegetation cover in mitigate UHI and moderate urban climate, an effective tree planting design is needed. One way to achieve this potential is to have a proper urban tree species selection by providing shade and cooling functions to pedestrians. Different tree species own different physical characteristics can provide different microclimate benefits (Sanusi et al., 2016). Studies have proven different tree characteristics influence the microclimate benefits through different leaf size, orientation, transpiration rates, and canopy shape (Lin & Lin, 2010; de Abreu-Harbich et al., 2015; Sanusi et al., 2017).

1.2 Problem Statement

Increased UHI phenomenon is growing and has raised concern to many countries (Wong & Yu, 2005; Roth, 2013). This phenomenon occurred was due to the rapid

urban development and population growth in cities (Ramakreshnan et al., 2018). The main factor contributing to UHI was land changes from green area to urban structure which allows city to absorb and trap solar radiation and heat waves (Jusuf et al., 2007). UHI caused increase in heat-related illness, energy demand in air-conditioning, air pollution, heat waves and even mortality (Roth, 2013).

Urban greenery or vegetation cover including tree planting are some strategies to reduce UHI effects. Trees in urban areas have potential to moderate urban climate by providing shade below canopy by either reflect or absorb incoming solar radiation and reducing temperature by evaporative cooling (Md. Tukiran et al., 2016). Tree shading and cooling effects are influenced by tree physical attributes such as canopy form, height, canopy, density and branching structure; leaves color and texture (Kotzen, 2003; Lin & Lin, 2010).

Studies on the impact of different tree species on microclimate benefits and conditions may provide important information regarding benefits can be provided by urban trees to cities which help better urban tree selection, street planning and management. Thus, the present study is also essential to assess and confirm the potential of urban street trees to provide microclimate benefits on street level and to address how different trees species influence the microclimatic condition to street pedestrians.

1.3 Objectives

The overall aim of this study is to investigate the influence of different street tree species on microclimatic conditions. There are two specific objectives, which were:

1. To evaluate the microclimate benefits of urban street trees
2. To determine the effects of different trees with different leaf and canopy characteristics on street microclimatic conditions

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