UNIVERSITI PUTRA MALAYSIA

ABUNDANCE OF SOIL INVERTEBRATES IN DIFFERENTLY-MANAGED LAND IN RELATION TO SOIL PHYSICOCHEMICAL PARAMETERS

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By

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

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October 2019

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The soil biota is considered as the biological engine of the earth and is associated in most of the critical functions of the soil in terms of ecosystem services. The knowledge on the impact of land management and agricultural activities on the abundance and diversity of soil invertebrates is still understudied especially in Malaysia. This study was conducted to investigate the soil-physico-chemical parameters from differently managed land around UPM. Next, is to measure the abundance and diversity of macro and microinvertebrates in differently managed land around UPM. Lastly is to obtain the relation between invertebrates' abundance with soil parameters. Sampling methods of soil invertebrates include pitfall trap and Burlese-Tullgren funnel. Invertebrate's abundance and diversity was measured and invertebrates were identified according to their morphological characteristics under the dissecting microscope with reference to taxonomic keys. Invertebrates were classified according to morphospecies and size which were macroinvertebrates and microinvertebrates. Additionally, the basic soil physical properties were also analysed using the rank-based method. A total of 5849 individuals were collected from 28 soil invertebrates' orders. Hymenoptera (83.93%) is the most dominant macroinvertebrates followed by Amphypoda (51.15%) and Orthoptera (13.62%). Hymenoptera is also the dominant microinvertebrates recorded (75.28%) followed by Acarina (52.59%) and Coleoptera (13.64%). Morphospecies diversity is the highest in durian farm (Shannon; 1.54) while, morphospecies evenness is the highest in vegetable farm (Evenness; 0.32) and morphospecies richness is highest in pasture land (Menhinick; 0.67). Reduced agricultural activities in durian farm, which recorded ideal soil physical parameters (soil porosity; 55.11 % ± 0.13 and soil temperature; 32.58 ºC ± 0.16) produces a comparatively more balanced habitat for a diverse community of soil invertebrates. CCA results suggest that soil moisture, soil temperature and soil EC are vital elements in the influence of soil invertebrate's abundance. Because of the roles they play in soil biological processes, soil invertebrates may be used as bioindicators of soil health. This study can be

used as a baseline for a more extensive research that may be applied in future planning on land management in achieving the nation's agricultural sustainability.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan unutk Ijazah Master Sains

BILANGAN INVERTEBRATA TANAH DI LOKASI YANG BERBEZA DARI SEGI PENJAGAAN DENGAN KAITAN KEPADA ASPEK FIZIKAL-KIMIA TANAH

Oleh

NURUL HAZIRAH BINTI HAMZAH

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Biota tanah boleh diklasifikasikan sebagai penjana sistem biologi bumi dan sering dikaitkan dengan pelbagai fungsi penting dalam ekosistem. Pengetahuan mengenai kesan pengurusan tanah dan kegiatan pertanian ke atas bilangan dan kepelbagaian invertebrata tanah masih lagi belum diketahui dengan sepenuhnya terutamanya di Malaysia. Objektif kajian ini ialah untuk mengkaji sifat fizikal-kimia tanah serta mengaitkannya dengan bilangan dan kepelbagaian makro dan mikroinvertebrata yang tinggal di tinggal di tanah yang diuruskan secara berbeza di beberapa lokasi di sekitar UPM. Akhir sekali, adalah untuk mendapatkan hubungan antara bilangan invertebrata dengan sifat fizikal-kimia tanah. Perangkap pitfall dan corong Burlese-Tullgren telah digunakan dalam proses persampelan tanah. Bilangan dan kepelbagaian invertebrata dinilai dan invertebrata dikenalpasti mengikut ciri-ciri morfologi mereka di bawah mikroskop dengan merujuk kepada kunci taksonomi. Invertebrata diklasifikasikan mengikut jenis dan saiz iaitu makroinvertebrata dan mikroinvertebrata. Di samping itu, sifat fizikal tanah juga dianalisis menggunakan kaedah berperingkat. Sebanyak 5849 individu telah dikumpulkan daripada 28 kelas invertebrata tanah. Hymenoptera (83.93%) adalah makroinvertebrata yang paling dominan diikuti oleh Amphypoda (51.15%) dan Orthoptera (13.62%). Manakala dalam kategori mikroinvertebrata, Hymenoptera juga adalah dominan (75.28%) diikuti oleh Acarina (52.59%) dan Coleoptera (13.64%). Ladang durian merekodkan kepelbagain species yang tertinggi (Shannon; 1.54), manakala ladang sayuran merekodkan kesamarataan yang tertinggi (Evenness; 0,32) dan kekayaan species adalah tertinggi di ladang lembu (Menhinick; 0.67). Kemungkinan kekurangan kegiatan pertanian di ladang durian dengan sifat fizikal tanah yang agak kondusif (kerongaan tanah; 55.11% ± 0.13 dan suhu tanah; 32.58 ºC ± 0.16) telah menghasilkan habitat yang agak seimbang untuk pelbagai jenis invertebrata tanah. Keputusan CCA menunjukkan bahawa kelembapan tanah, suhu tanah dan kekonduksian elektrik tanah adalah unsur penting yang mempengaruhi bilangan invertebrata tanah. Berdasarkan peranan mereka dalam sistem

biologi tanah, invertebrata tanah berpotensi digunakan sebagai rujukan untuk mengenalpasti kesuburan tanah. Kajian ini boleh digunakan sebagai panduan untuk penyelidikan yang lebih mendalam dan membantu perancangan pengurusan tanah pada masa hadapan demi mencapai kemampanan pertanian negara.

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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:

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CHAPTER 1

INTRODUCTION

1.1 Current issues on soil health

Healthy soil is the basis of agriculture and a vital resource to secure human demands in the 21st century as well as to many terrestrial organisms since soil is required for much of the primary, secondary and tertiary production. Almost all the food chains depend on the soil directly or indirectly thus making it a key component of ecosystems and earth system functions that sustain the delivery of principal ecosystem services (Borrelli, 2017). Soil is a rich habitat for a massive number of bacteria, algae, fungi, worms, insects, small vertebrates and plants. Soil microbes have been characterized by some as the 'probiotics' of the plant world (Logan, 2018). Soil health can be described by the concept of maintained capacity and important living system to sustain a diverse group of soil organisms known as biota. Additionally, healthy soil is a vital contribution in the mitigation of climate change via carbon assimilation.

However, as world population increase, more emphasis is placed on sufficient food production which have resulted in a large-scale proliferation and intensification of crop production that involves the application of agrochemicals and rigorous land usage. This has consequently led to environmental issues such as pollution, soil depletion and degradation as well as climate change which have altered soil moisture and soil acidity after decades of heavy use of agrochemicals and intensive land usage. Some agriculture land is becoming irresponsive to agrochemical input, are prone to disease incidence and declining yield; this emerging phenomenon is known as dead soil. Soil, which is regarded as a neglected resource, can solve many of the environmental issues that human face as it indeed the basis of life. Before remedial action against dead soil syndrome can be taken, it is imperative to understand the factors that decline agricultural yield, high incidence of disease, and depletion of flora and fauna diversity in the soil. According to the first global scientific review, the world's insects are racing down the passage of extinction, resulting in a calamitous collapse nature's ecosystem. Industrial-scale, intensive agriculture, urbanization, and climate change are the major cause of the depletions, especially the heavy utilization of pesticides. If this occurrence of species loss cannot be impeded, it will lead to catastrophic consequences for both Earth's ecosystems and for the survival of mankind.

1.2 Tangible mitigations

Some pioneering work indicated that dead soil is devoid of flora and fauna diversity of healthy virgin soil. This is understandable because in many countries around the globe, soil sciences are primarily concerned on the physico-chemical characteristics of soil. From the physical soil aspect, the use of heavy machinery has cause soil compaction thus consequently decreases rain infiltration and soil aeration which are equally both vital for crop root development. Whereas from the chemical soil characteristics, the employment of fungicide destroys many beneficial soil mycorrhizal fungi, which inhabit plant roots and garner nutrients and minerals from the soil to help their growth (Smith, 2018).

Sustainable agricultural practices like intercropping and crop rotation helps to promote healthy soil by regulating the soil nutrient and decrease the activity of pests (Hoe-Han, 2018). This is especially applicable to small-scale farmer in Malaysia as manure form livestock act as organic fertilizer or feed for aquaculture and multiple cropping may diversify produce. In contrast, large-scale farmers managing oil palm or rubber plantations, are typically reliant on the heavy use of chemical fertilisers or agrochemicals which in turn may be detrimental to soil biota when applied excessively. The maintenance of soil health is vital in the prevention of plant diseases and sustaining crop yield is important in ensuring food security as well as maintaining a balanced ecosystem of soil biota for biodiversity (Logan, 2018). Presently, there is a concept of regenerative agriculture to recover the loss of infertile soils by organic farming, like conservation tillage, cover crops, composting, biochar and pasture cropping (Hoe-Han, 2018). Indeed, soil health should be considered as the basis of agriculture as it helps feed the world and mitigate climate change and environmental degradation.

1.3 Limitations on the present approach

Currently, there has been a limitation in the present approach in which the term 'living soil' is still foreign to many soil scientists. Until now, numerous studies have been carried out mostly on the physical and chemical aspect of soil and less on the biological perspective of soil. There is indeed a lack of literature on soil health and its influence on the wellbeing of crop production. Therefore, this proposed project may contribute to the severe limitations by providing a baseline information towards linking biological aspect with the activity of soil.

1.4 Significance of study

Recently, soil scientists have made tremendous development towards understanding soil organisms and their function in ecosystems. Nevertheless, there is more to be found in

order to allow the growth of practices that will encourage the sustainable application of soils. A comprehension of what creates alterations in the below ground biodiversity an how diversity is related to soil function would assist in the sustainability and restoration of ecosystems (Brevik et al., 2015).

As a matter of fact, many of the Sustainable Development Goals (SDGs) are closely associated to soil health. Enhancing soil quality is a fundamental move towards attaining the SDGs on zero hunger (SDG 2), climate action (SDG 13), and life on land (SDG 15), which set the preliminary work in our pursuit to reach a healthy and sustainable future for our planet. Soil is vital for goal 2 which is ending world hunger by ensuring food security and refined nutrition through fostering sustainable agriculture (Agrocares, 2019). In addition, soils are involved in the mitigation of climate change (SDG 13) as it is the world's biggest carbon sink and may assist in altering climate change via carbon sequestration and depletion of greenhouse gas emissions (One Acre Fund, 2019). Lastly, soil is highly related to goal 15 which emphasized on confronting desertification and restoring degraded soil. To guarantee sufficient food resources for the increasing number of world population, means we cannot afford to lose more fertile land. Thus, we have to focus on soil rehabilitation and land restoration.

Maintaining soil sustainability is important because the present food production heavily relies on soil. It can be said that soil is critical part of the food security. Unfortunately, there is almost non-existence information on soil flora and fauna in uncultivated soil, intensively cultivated soil, semi intensive cultivated soil and others. Therefore, to furnish more information on soil flora and fauna, it is imperative to undertake basis ecological studies on soil flora and fauna. However due to limited resources and time constrain, this study pays more attention on soil fauna only. This study investigates soil fauna abundance and diversity in cultivated and non-cultivated soil around UPM campus. The objective of this study are as follows.

1.5 Objectives

There are three main objectives in this research as follows:

1. To investigate the soil-physico-chemical parameters from differently managed land around UPM.
2. To measure the abundance and diversity of macro and microinvertebrates in differently managed land around UPM.
3. To obtain the relation between invertebrates abundance with soil parameters.

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