CHARACTERIZATION OF SOIL TREATED AND OPTIMIZATION STUDIES ON AB MIX NUTRIENTS USAGE TOWARDS CAPSICUM FRUTESCENS

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ABSTRACT

This thesis investigates the characterization of soil treated with AB mix nutrients and the optimization of its usage towards *Capsicum frutescens* (*C. frutescens*) cultivation. Driven by the need to address the environmental issues arising from excessive fertilizer usage that exceeds recommended guidelines, this study aims to determine optimal nutrient application rates that are environmentally sustainable while maintaining agricultural productivity. Employing characterization techniques such as Inductively Coupled Plasma - Optical Emission Spectroscopy (ICP-OES), Energy-Dispersive X-Ray Fluorescence (EDXRF) and Vector Network Analysis (VNA), the research identifies elemental composition and evaluates soil dielectric properties. EDXRF analysis revealed significant detection of elements spectrum in the soil at different energy ranges; the several elements detected were aluminium (Al), sulphur (S) and chlorine (Cl), where the element intensities observed vary with the electrical conductivity (EC) levels of AB mix nutrient. This analysis provided detailed elemental composition of the soil, revealing notable increases in elements such as aluminium (Al), which was detected at 2227.105 cps/mA at the lowest EC value, 1.4 mS/cm to 3031.773 cps/mA at 3.5 mS/cm. The highest dielectric constant, ε' of the soil sample was observed at 1.4 mS/cm with 6 mL of AB mix nutrients, with the value of 2.2 mS/cm, whilst the lowest dielectric constant, ε' was recorded by the controlled sample with ~1.1208. As for the VNA measurements, results showed that higher applications of nutrients generally resulted in lower *S*-parameter values (S_{11} and S_{21}), reflecting changes in the soil's electromagnetic properties due to varying nutrient concentrations. As the X-band frequency increased, the real and imaginary parts of *S*-parameters demonstrated distinct trends. The real S_{11} (reflection coefficient) and S_{21} (transmission coefficient) typically decreased with the increasing frequency, f indicating reduction in signal reflection and transmission efficiency as the nutrient concentration increased. Conversely, the imaginary parts of S-parameters showed variations that suggest complex interactions between the electromagnetic waves and the soil's physical properties, reflecting changes in the soil's dielectric constant, ε'. For further understanding on AB mix nutrients concentration effect towards the *C. frutescens* growth, Response Surface Methodology software (RSM) was employed. Result showed that the optimal conditions of the AB mix nutrients for *C. frutescens* were recorded at the concentration of 2.54 mS/cm of AB mix nutrients and the wick length of 18.15 cm. Under these conditions, the maximum plant's height simulated using Analysis of Variance (ANOVA) and RSM was 38.73 cm, which was comparable with the experimental result that recorded 40.2 cm as the maximum height. In short, this research provides an understanding of AB mix nutrient properties, the interaction of nutrients on soil with the microwave frequency, f and the optimum condition of *C. frutescens* growth using fertigation Nutri-pot system. These findings highlight the importance of good fertilizer practices that adapt to specific soil characteristics, promoting sustainable agriculture by optimizing fertilizer use, thereby reducing environmental impact and supporting effective crop growth.

ABSTRAK

Tesis ini mengkaji pencirian tanah yang dirawat dengan nutrien campuran AB dan pengoptimuman penggunaannya untuk penanaman *Capsicum frutescens* (*C. frutescens*). Berpandukan keperluan untuk mengatasi isu-isu alam sekitar yang timbul daripada penggunaan baja yang berlebihan melebihi garis panduan yang disyorkan, kajian ini bertujuan untuk menentukan kadar penggunaan nutrient yang optimum yang mesra alam sekitar sambil mengekalkan produktiviti pertanian. Dengan menggunakan teknik pencirian seperti Spektroskopi Emisi Optik - Plasma Berkaitan Induktif (ICP-OES), Pendarfluor Sinar-X Tenaga Serakan (EDXRF) dan Analisis Rangkaian Vektor (VNA), penyelidikan ini mengenal pasti komposisi unsur dan menilai sifat dielektrik tanah. Analisis EDXRF menunjukkan pengesanan yang signifikan bagi unsur-unsur seperti aluminium (Al), sulfur (S) dan klorin (Cl), dengan kepekatan yang berubah dengan tahap kekonduktivitian elektrik (EC) nutrien campuran AB. Analisis ini memberikan komposisi unsur terperinci tanah, mendedahkan peningkatan ketara dalam unsur seperti aluminium (Al), yang dikesan pada 2227.105 cps/mA pada tahap EC terendah, 1.4 mS/cm kepada 3031.773 cps/mA pada 3.5 mS/cm. Pemalar dielektrik tertinggi, ε' sampel tanah diperhatikan pada 1.4 mS/cm dengan 6 mL nutrien campuran AB, dengan nilai 2.2 mS/cm, manakala pemalar dielektrik terendah, ε' dicatatkan oleh sampel kawalan dengan ~1.1208. Bagi pengukuran VNA, hasil menunjukkan bahawa aplikasi nutrien yang lebih tinggi secara amnya menghasilkan nilai parameter-*S* (S_{11} dan S_{21}) yang lebih rendah, mencerminkan perubahan dalam sifat elektromagnet tanah akibat variasi kepekatan nutrien. Apabila frekuensi X-band meningkat, bahagian nyata dan khayalan parameter-*S* menunjukkan trend yang ketara. S_{11} nyata (pekali pantulan)

dan S_{21} (pekali penghantaran) biasanya menurun dengan peningkatan frekuensi, *f* menunjukkan pengurangan dalam kecekapan pantulan dan penghantaran isyarat apabila kepekatan nutrien meningkat. Sebaliknya, bahagian khayalan parameter-*S* menunjukkan variasi yang mencadangkan interaksi kompleks antara gelombang elektromagnet dan sifat fizikal tanah, mencerminkan perubahan dalam pemalar dielektrik tanah, ε'. Untuk pemahaman lanjut mengenai kesan kepekatan nutrien campuran AB terhadap pertumbuhan *C. frutescens*, perisian Kaedah Permukaan Tindak Balas (RSM) digunakan. Hasil menunjukkan bahawa keadaan optimum bagi nutrien campuran AB untuk *C. frutescens* dicatatkan pada kepekatan 2.54 mS/cm nutrien campuran AB dan panjang sumbu 18.15 cm. Di bawah keadaan ini, ketinggian maksimum tumbuhan yang disimulasikan menggunakan Analisis Varians (ANOVA) dan RSM adalah 38.73 cm, yang sebanding dengan hasil eksperimen yang mencatatkan 40.2 cm sebagai ketinggian maksimum. Secara ringkas, kajian ini memberikan pemahaman tentang sifat nutrien campuran AB, interaksi nutrien pada tanah dengan frekuensi gelombang mikro, *f* dan keadaan optimum pertumbuhan *C. frutescens* menggunakan sistem Nutri-pot fertigasi. Penemuan ini menekankan kepentingan amalan baja yang baik yang disesuaikan dengan ciri-ciri tanah tertentu, mempromosikan pertanian mampan dengan mengoptimumkan penggunaan baja, seterusnya mengurangkan impak terhadap alam sekitar dan menyokong pertumbuhan tanaman yang berkesan.

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APPROVAL

The Examination Committee has met on **23 August 2024** to conduct the final examination of **Nur Dinie Syahirah binti Sanusi** on his degree thesis entitled **'Characterization of Soil Treated and Optimization Studies On AB Mix Nutrients Usage Towards *Capsicum Frutescens*' .**

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LIST OF ABBREVIATIONS

UPNM	-	University Pertahanan Nasional Malaysia
C. Frutescens	-	*Capsicum Frutescens*
ICP-OES	-	Inductively Coupled Plasma - Optical Emission Spectroscopy
EDXRF	-	Energy-Dispersive X-Ray Fluorescence
VNA	-	Vector Network Analysis
EC	-	Electrical Conductivity
RSM	-	Response Surface Methodology
ANOVA	-	Analysis of Variance
NPK	-	Nitrogen-Phosphorus-Potassium
DOA	-	Department Of Agriculture
WAP	-	Week After Planting
EM	-	Electromagnetic
DC	-	Direct Current
CCD	-	Central Composite Design
MNDT	-	Microwave Non-Destructive Technique
NFT	-	Nutrient Film Technique
ATP	-	Adenosine Triphosphate
LMO	-	Local Microorganisms
NUE	-	Nitrogen Use Efficiency
WUE	-	Water Use Efficiency
OM	-	Organic Matter
PVC	-	Polyvinyl Chloride
FRIM	-	Forest Research Institute Malaysia
RISDA	-	Rubber Industry Smallholders Development Authority
NRW	-	Nicholson-Ross-Weir

LIST OF SYMBOLS

ε'	-	Dielectric constant
ε''	-	Dielectric loss / imaginary part of permittivity
T	-	Temperature
θ	-	Angle of incidence / phase signal
λ	-	Wavelength
f	-	Frequency
C	-	Carbon
P_2O_5	-	Phosphorus pentoxide
K_2O	-	Potassium oxide
MgO	-	Magnesium oxide
CaO	-	Calcium oxide
Fe	-	Iron
Co	-	Cobalt
Ca	-	Calcium
Ni	-	Nickel
Pb	-	Lead
B	-	Boron
Mg	-	Magnesium
Mn	-	Manganese
Cu	-	Copper
Zn	-	Zinc
Cr	-	Chromium
H_4SiO_4	-	Silicic acid
HCl	-	Hydrochloric acid
HOCl	-	Hypochlorous acid
SiO_2	-	Silicon dioxide

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CHAPTER 1

INTRODUCTION

1.1 Introduction to Fertilizers

Fertilizers are substances applied to soil or plants to provide essential nutrients that support plant growth and development. They supply nutrients that may be deficient in the soil, promoting healthier plants and increase crop yields. Fertilizers replenish the nutrients ensuring crops have access to the elements needed for optimal growth. Nutrient-rich soil leads to healthier plants with increased productivity (De Bon et al., 2010). Adequate nutrients result in larger, higher-quality harvests, contributing to farmers' food security and economic prosperity (Nadarajan & Sukumaran, 2021).

Fertilizers provide a balanced ratio of nutrients, promoting uniform growth across various plant parts. This balanced development enhances plant structure, making them better equipped to withstand environmental stressors such as drought, pests, and diseases (Rakshit et al., 2012). The three (3) primary nutrients contain in fertilizers are nitrogen, (N), phosphorus, (P) and potassium, (K) along with various micronutrients; nitrogen, (N) supports leaf and stem development, phosphorus, (P) encourages root growth and flowering and potassium, (K) enhances plant vigour and disease resistance (Lin et al., 2019). These essential compounds provide plants with the nutrients they need for healthy growth, improved yield and overall agricultural sustainability (Hemathilake & Gunathilake, 2022). Another important feature of fertilizers is they offer a rapid and targeted response to nutrient deficiencies. This is particularly important when quick nutrient supplementation is needed to rectify deficiencies and prevent yield losses during critical growth stages. It has been reported that fertilizers can be tailored to specific crops and soil conditions, allowing farmers to meet the unique nutrient requirements of different plants (Silveira & Kohmann, 2020). Precision in nutrient application leads to efficient resource utilization and reduces the risk of nutrient wastage or environmental pollution.

There are two (2) types of fertilizers i.e. organic and inorganic. Organic fertilizers, which are derived from natural materials, such as plants and animal residues, provide nutrients to plants in less concentrated and more gradual manner compared to inorganic fertilizers. Unlike inorganic fertilizers, organic fertilizers need to undertake the decomposition process by soil microorganisms, which may take some time before their nutrients become available to plants (Pahalvi et al., 2021). Therefore, to increase the production of crops in a short time, inorganic fertilizers are often used.

Inorganic fertilizers, also known as synthetic or chemical fertilizers, are nutrient-rich compounds manufactured through industrial processes. Unlike organic fertilizers, the inorganics are chemically synthesized to contain specific ratios of nutrients that are vital for plant growth and development (Pahalvi et al., 2021). In addition to Nitrogen-Phosphorus-Potassium (NPK), inorganic fertilizers may also contain various micronutrients like iron, zinc, copper, manganese, molybdenum and