Hydrothermal Synthesis of Zeolite from Low Grade Kaolin: Application as Soil Amendment and Nutrient Retention to Increase the Cherry Tomato *(Cherry Solanum lycopersicum var. cerasiforme*) Yield

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My love and special dedication for my husband, Mohamad Salehin bin Abd Rahim, my daughter, Norsurfina binti Mohamad Salehin, my parents, Sazali bin Kandar & Soliah binti Adinan, and my siblings (Norzalyana, Dr. Norazlianie, Mohamad Suzaime, and Mohamad Suzaidie). Thank you for everything, and I am forever grateful for all of the kindness and encouragement given throughout my journey in completing this project. May Allah S.W.T repay all of you accordingly. Amin.

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ABSTRACT

Zeolite- Linde Type A (LTA) is widely known as an aluminosilicate mineral that has been intensively used as a soil amendment and water retention in the agriculture sector to increase the growth of the plant. The proposed hydrothermal synthesis of zeolite-LTA in this current work from kaolin (Delta Corp Sdn Bhd) via controlling the molarity of NaOH during aging and crystallization time has shown higher crystallinity percentage of yield (88.45%) at lower molarity of 1M NaOH and 9hrs minimum crystallization time. The performance of zeolite LTA as a soil amendment and water retention was further analyzed in cherry tomato growth in seven different condition in determining the optimum ratio of soil and fertilizer. The implementation of Least Significant Difference (LSD) post-hoc test ($P \leq 0.05$) enable the effectiveness measurement all soil treatments towards the plant growth and leaching analysis. Analysis from the obtained results of plant growth including plant height, number of leaves, stem width diameter, revealed that the 6g of zeolite amended in soil has a higher significant difference towards the other treatments. For bulk density, 6g of zeolite shows a highly significant response and effect difference towards compared to other treatments. For the chemical analysis, in CEC, 6g of zeolite shows a significant difference from other treatments at harvest 1, 2 and 3. The availability of nutrients in the soil (mean K, Na, Ca and Mg), at all harvests, 6g of zeolite show significant difference of mean K and Mg toward other treatments. Analysis from all results performance's experiments suggest that indicates that 6g of zeolite has the most potential as of soil amendments for both plant growth and controlled-release applications. This study revealed that the addition of zeolite is not only able to increase the yield harvest of production via improvement enhancement of nutrient efficiency uptakes but also reduce the utilization of fertilizer that able to minimize the cost and pollution which is one way of reducing carbon footprints due to pollution.

ABSTRAK

Zeolite- Linde Type A (LTA) dikenali secara meluas sebagai mineral aluminosilikat yang telah digunakan secara intensif sebagai pindaan tanah dan pengekalan air dalam sektor pertanian untuk meningkatkan pertumbuhan tumbuhan. Kaedah sintesis zeolit-LTA yang dicadangkan dalam kajian ini adalah daripada kaolin (Delta Corp Sdn Bhd) melalui kawalan kemolaran NaOH semasa penuaan dan masa penghabluran telah menunjukkan peratusan kehabluran hasil yang lebih tinggi (88.45%) pada kemolaran rendah 1M NaOH dan 9 jam minimum masa penghabluran. Prestasi zeolit LTA sebagai pindaan tanah dan pengekalan air dianalisis selanjutnya dalam pertumbuhan tomato ceri dalam tujuh keadaan berbeza dalam menentukan nisbah optimum tanah dan baja. Pelaksanaan ujian post-hoc Least Significant Difference (LSD) ($P \leq 0.05$) membolehkan pengukuran keberkesanan semua rawatan tanah terhadap analisis pertumbuhan tumbuhan dan larut lesap. Analisis daripada ketinggian tumbuhan, bilangan daun, diameter lebar batang, menunjukkan bahawa 6g zeolit yang dipinda dalam tanah mempunyai perbezaan ketara yang lebih tinggi berbanding rawatan lain. Untuk ketumpatan pukal, 6g zeolit menunjukkan tindak balas dan perbezaan kesan yang sangat ketara berbanding rawatan lain. Bagi analisis kimia, dalam CEC, 6g zeolit menunjukkan perbezaan yang ketara daripada rawatan lain pada penuaian 1, 2 dan 3. Ketersediaan nutrien dalam tanah pada semua penuaian, 6g zeolit menunjukkan perbezaan purata K dan Mg yang signifikan terhadap rawatan lain. Analisis daripada semua keputusan termasuk eksperimen prestasi kapasiti pertukaran kation (CEC) menunjukkan bahawa 6g zeolit mempunyai potensi paling besar dalam pindaan tanah untuk kedua-dua pertumbuhan tumbuhan dan aplikasi pelepasan terkawal. Kajian ini mendedahkan bahawa penambahan zeolit bukan sahaja dapat meningkatkan hasil pengeluaran tetapi juga mengurangkan penggunaan baja yang mampu meminimumkan kos.

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LIST OF SYMBOLS AND ABBREVIATIONS

AAS	-	atomic absorption spectrometry
ANOVA	-	Analysis of variance
Al_2O_3	-	Aluminium oxide
ATP	-	the energy unit of plants
$BaCl_2$	-	Barium Chloride
$B(OH)_3$	-	boric acid
BET	-	Brunauer-Emmett-Teller
CEC	-	cation exchange capacity
Ca	-	Calcium
cm^3/d	-	centimetre cube per day
cm	-	centimeter
Cs^+	-	Cesium ion
CO_2	-	carbon dioxide
$CuSO_4$	-	Copper Sulphate
d	-	core ring diameter (cm)
EDS	-	Energy-dispersive X-ray spectroscopy
EDTA	-	Ethylenediaminetetraacetic acid
FAU	-	Faujisite Topology
FTIR	-	Fourier transform infrared spectroscopy
FESEM	-	Field emission scanning electron microscopy
GDP	-	Malaysia's Gross Domestic Product
GH	-	Greenhouses
g/pot	-	gram per pot
g	-	gram
HCl	-	Hydrochloric acid
H_2SO_4	-	Sulphuric acid

HNO_3	-	nitric acid
h	-	height of core ring (cm)
ICDD	-	International Centre for Diffraction Data
IC	-	ion chromatography
K	-	Potassium
LTA	-	Linde Type A
LSD	-	Least Significant Difference
Li^+	-	Lithium ion
meq g^{-1}	-	Miliequivalent per gram
m	-	meter
M	-	Molarity
ml	-	millilitre
Mg	-	Magnesium
MCO	-	Movement Control Order
MARDI	-	Malaysian Agricultural Research and Development Institute
NKEA	-	National Key Economic Areas'
NH	-	net houses
Na^+	-	sodium ion
NR	-	nitrate reductase
NaOH	-	Sodium hydroxide
NPK	-	Nitrogen, Phosphorus, and Potassium
Na	-	Sodium
Na_2SO_4	-	Sodium sulphate
NH_3	-	Ammonia
nm	-	Nanometer
NO_3	-	Nitrate
NO_2	-	Nitrite
ppb	-	parts-per-billion
ppm	-	parts-per-million
Pb	-	Bulk Density
PBU	-	Primary Building Unit
PO_4^{3-}	-	Phosphate
RS	-	rain shelters
Rb^+	-	Rubidium ion

SiO_2	-	silicon dioxide
SBU	-	Secondary Building Unit
SOD	-	sodalite
TEOS	-	Tetraethyl Orthosilicate
TGA/DTA	-	Thermogravimetry/differential thermal
Wb	-	weight of the media and core ring after oven drying (g)
Wr	-	weight of core ring (g)
XRD	-	X-ray powder diffraction
µM	-	Micrometer

LIST OF EQUATION

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