THE STUDY OF CONTROLLED RELEASE PROPAGATING SUBSTRATE (CRPS) AND NPK-ORGANO-ZEOLITE ON THE GROWTH OF *CLINACANTHUS NUTANS*

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Dedicated to:

My beloved parents,

Mr Haji Abdullah bin Ishak & Mrs Hajah Normah binti Hassan

my siblings,

Haryati Abdullah & Siti Nazirah Abdullah

my lecturers,

and my friends,

who give me strength and full support,

Thank you from the bottom of my heart.

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ABSTRACT

The study was carried out to investigate the performance of Controlled Release Propagating Substrate (CRPS®) and NPK-Organo-Zeolite® for the growth of *Clinacanthus nutans (Belalai Gajah)*. Natural zeolite (clinoptilolite) was modified with cationic surfactant hexadecyltrimethylammonium (HDTMA) for nitrogen (N), phosphorus (P) and potassium (K) elements adsorption producing NPK-Organo-Zeolite®. Then, the NPK-Organo-Zeolite® was characterized with X-ray diffraction technique (XRD) and Fourier transform-infrared spectroscopy (FTIR). Column leaching test was performed to study the release behavior of ammonium (NH_4^+), phosphate (PO_4^{3-}) and potassium (K^+) from NPK-Organo-Zeolite® in 15 days. NPK-Organo-Zeolite® released the nutrients slower than commercial fertilizer. CRPS® was used for sowing the *C.nutans* and then the NPK-Organo-Zeolite® was applied for the growth of the plant. The growth of *C.nutans* was investigated after 75 days. The optimization study of the plant growth was also performed in term of the optimized weight of NPK-Organo-Zeolite®. The results showed that the growth of *C. nutans* applied with CRPS® and NPK-Organo-Zeolite® produced better results as compared to propagating substrate only and the application of commercial fertilizer in terms of plant height, number of leaf, fresh weight and dry weight. It can be concluded that CRPS® and NPK-Organo-Zeolite® possessed slow release behavior as they can remain longer in the soil and enhanced the plant growth.

ABSTRAK

Kajian ini telah dijalankan untuk menyiasat prestasi medium semaian kawalan (CRPS®) dan baja NPK-Organo-Zeolite® untuk pertumbuhan *Clinacanthus nutans* (Belalai Gajah). Zeolit asli (klinoptilolit) telah diubahsuai dengan kationik surfaktan hexadesiltrimetilammonium (HDTMA) untuk penyerapan elemen nitrogen (N), fosforus (P) dan kalium (K) bagi menghasilkan baja NPK-Organo-Zeolite®. Kemudian, NPK-Organo-Zeolite® dicirikan dengan teknik pembelauan sinar-X (XRD) dan spektroskopi inframerah (FTIR). Ujian ruangan larut lesap telah dijalankan untuk mengkaji tingkah laku pembebasan ammonium (NH_4^+), fosfat (PO_4^{3-}) dan kalium (K^+) untuk baja NPK-Organo-Zeolite® dalam masa 15 hari. Baja NPK-Organo-Zeolite® telah menunjukkan pembebasan nutrien secara perlahan berbanding baja komersial. CRPS® telah digunakan untuk menyemai pokok *C.nutans* dan kemudian baja NPK-Organo-Zeolite® telah digunakan untuk pertumbuhan pokok tersebut. Pertumbuhan *C.nutans* dikajikan selepas 75 hari. Kajian mengoptimumkan pertumbuhan tanaman juga telah dilakukan dari aspek berat baja NPK-Organo-Zeolite® yang optimum. Hasilnya menunjukkan bahawa penggunaan CRPS® dan baja NPK-Organo-Zeolit® dalam pertumbuhan pokok *C.nutans* telah menghasilkan keputusan yang lebih baik berbanding dengan penggunaan substrat pembiakan sahaja dan penggunaan baja komersial dari aspek ketinggian tumbuhan, bilangan daun, berat basah dan berat kering. Kesimpulannya, CRPS® dan NPK-Organo-Zeolite® mempunyai tingkah laku pembebasan nutrien secara perlahan di mana nutrien boleh kekal lebih lama di dalam tanah dan meningkatkan pertumbuhan tumbuhan.

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LIST OF SYMBOLS

θ	-	Theta
°C	-	Degree celcius
%	-	Percentage
®	-	Registered Trademark
cm	-	Centimeter
cm^{-1}	-	Reciprocal Centimetre or Reciprocal Wavelength
g	-	Gram
mM	-	Millimolar
mg/L	-	Milligram per litre
mL	-	Millilitre
rpm	-	Revolutions per minute

LIST OF ABBREVIATIONS

CEC	-	Cation Exchange Capacity
Cli	-	Clinoptilolite
CRPS	-	Controlled Release Propagating Substrate
C. nutans	-	*Clinacanthus nutans*
FTIR	-	Fourier transform infrared
HDTMA	-	Hexadecyltrimethylammonium
HDTMA-Br	-	Hexadecyltrimethylammonium-bromide
H_2O	-	Water molecules
HSV	-	Herpes simplex virus
SMC	-	Surfactant modified clinoptilolite
SMSs	-	Surfactant modified silicates
SMZ	-	Surfactant modified zeolite
SRF	-	Slow release fertilizer
VZV	-	Varicella-zooster virus
XRD	-	X-ray diffraction

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Fertilizers are added to soil to supply nutrients required for plant growth. Though, only a small fraction of the chemical nutrients are absorbed by the soil or reaches the target site for the plant to take up and partial of the applied fertilizers are lost to the environment, which results in various environmental bad impacts such as contamination of surface water and excessive dissolved solids in groundwater. The use of conventional fertilizers may lead to the high concentration levels of nutrients which may produce undesirable side effects on the target site and the environment (Tomaszewska, 2003; Diwani *et al.*, 2013). High amounts of nutrient constituents such as nitrogen, potassium, phosphorus, metal ions and synthetic organic chemicals in surface water bodies may lead to eutrophication (Bansiwal *et al.*, 2006; Bhardwaj *et al.*, 2012; Malekian *et al.*, 2011). In normal fertilizers, almost 40–70% of the nitrogen is lost to the environment and cannot be absorbed by plants (Corradini *et al.*, 2010) which responsible for serious environmental contamination. Growth is reduced when the amount of nitrogen in soil is not optimal (Sepaskhah and Barzegar 2010). Therefore, sustainable approach is needed to solve these problems such as by the addition of zeolite in fertilizer.

Zeolite can be effectively used in cultivating a number of crops such as fruit and vegetables where the zeolite aids in preventing excessive losses of nutrients, thus making them available when needed (Milosevic and Milosevic, 2009). Clinoptilolite is the most common zeolite used in agricultural applications due to its high cation exchange and adsorption capacities (Polat *et al.*, 2004). Dzkulfli *et al.* (2014) has reported that clinoptilolite modified with surfactant and added with propagating substrate to produce controlled release propagating substrate (CRPS®) can hold nutrient release. CRPS® has been filed for patent with identification number: PI 2014702589 (Malek *et al.*, 2014). The novelty of this CRPS was surfactant modified clinoptilolite (SMC) added to propagating substrate in ratio 1:50 – 15:50.

Complete NPK (Nitrogen, phosphate and potassium) nutrients for okra plants growth has been reported using NPK-Organo-Zeolite® in previous research (Hamzah *et al.*, 2014). The natural zeolite type clinoptilolite can be modified using surfactant and perform as a carrier for phosphate, nitrogen and potassium (Hamzah *et al.*, 2014). Li *et al.* (2013) also reported that zeolite could be modified by surfactant as slow release fertilizer carriers to control nitrate, phosphate and sulfate release. NPK-organo-zeolite® as advanced controlled release fertilizer that has been filed for patent recently with identification number: PI 2014703213 (Malek *et al.*, 2014). The novelty of this NPK-Organo-Zeolite was surfactant modified zeolite which has complete NPK (Nitrogen, phosphate and potassium) nutrients fertilizer. Yet, there is no control release behavior of NPK-organo-zeolite® and its performance as fertilizer has been reported especially for herb of *Clinacanthus nutans.*

1.2 Problem Statement

One of the major reasons for contamination of groundwater in agricultural farmland is the use of soluble nitrogen fertilizers. Since nitrate is in an anionic form and due to the net repulsion between the anions and soil surfaces, it will be excluded

from the soil surfaces and is easily leached. Therefore, the release of nitrogen from fertilizer needs to be controlled. Thus, it is of great interest to use technology that can increase fertilizer efficiency and reduce nitrate leaching (Malekian *et al.*, 2011). The imbalance between the rates of nutrient uptake by plant roots and the rates of nutrient release from fertilizers make the fertilizers less effective. It is important to use slow release fertilizers (SRFs) that are capable of releasing nutrients slowly compared to conventional fertilizers. Modifying zeolite with surfactant able to control phosphate, nitrate and sulfate release and act as slow release fertilizer carriers (Li *et al.*, 2013; Bhardwaj *et al.*, 2012). Hence, it is important to add zeolite as one of the main elements in the fertilizer compound to control the release of nutrients (Malek *et al.*, 2014)

According to Bansiwal *et al.*, (2006) slow release fertilizer based on zeolites is limited to nutrients only in cationic forms such as K^+ and NH_4^+. On the other hand, the loading of anionic forms nutrients such as NO_3^- and PO_4^- are negligible on original zeolites. Since surfactant-modified zeolite (SMZ) is used to remove anionic contaminants from water, the natural zeolites cation-exchange properties can be exploited by modifying their surface thus retaining anions and non-polar organics properties (Alias *et al.*, 2009). A cationic surfactant hexadecyltrimethylammonium (HDTMA) that possesses a permanent positive charge was used to modify zeolite to maximize its capacity of nitrate retention (Malekian *et al.*, 2011; Li, 2003). Therefore, by modifying natural zeolite with cationic surfactant helps to hold anionic forms nutrients in slow release fertilizer.

1.3 Objectives of the Research

The main aims of this research were:

i. To characterize controlled release propagating substrate (CRPS®) and NPK-Organo-Zeolite® using XRD and FTIR techniques.
ii. To observe the release of ammonium (NH_4^+), phosphate (PO_4^{3-}), and potassium (K^+) from NPK-Organo-Zeolite®.
iii. To investigate the effect of CRPS® as controlled release propagating substrate and NPK-Organo-Zeolite® as a control release fertilizer on the growth performance of *Clinacanthus nutans*.

1.4 Scope of the Research

The main scope of this study can be divided into three stages. Firstly, CRPS® was prepared to be used in growth performance of *C.nutans*. CRPS® was prepared by adding surfactant modified clinoptilolite (SMC) with propagating substrate. SMC was prepared by modified the clinoptilolite with cationic surfactant hexadecyltrimethylammonium (HDTMA). Then, the preparation and characterization of NPK-Organo-Zeolite® were performed. The characterization of this NPK-Organo-Zeolite with X-ray diffraction (XRD) and Fourier transform infrared (FTIR) spectroscopy provides information on the structure of zeolite and the presence of surfactant HDTMA on the zeolite.

Secondly, the release of ammonium (NH_4^+), phosphate (PO_4^{3-}), and potassium (K^+) from NPK-Organo-Zeolite® was investigated using column leaching test and analysed by visible spectrophotometer with the aid of kits. This column leaching test was analysed in 15 days.

Thirdly, two studies were conducted for plant growth study. Initially, CRPS® was used for sowing *C. nutans* and study its growth performance as controlled release propagating substrate, then NPK-Organo-Zeolite® was applied for the growth of the plant and study its growth performance as slow release fertilizer. Subsequently, the optimization study of the plant growth was performed in term of the optimized weight of NPK-Organo-Zeolite® from 0.0 g, 0.1 g, 0.5 g, 1.0 g, 5.0 g, 10.0 g, 15.0 g, 20.0 g and 25.0 g. There were several parameters that have been focused on which were plant height, leaf number, fresh weight and dry weight. ANOVA was used in statistical analysis study for the growth performance and optimization study of the plant growth. The flow diagram of the research design is shown in Figure 1.1.

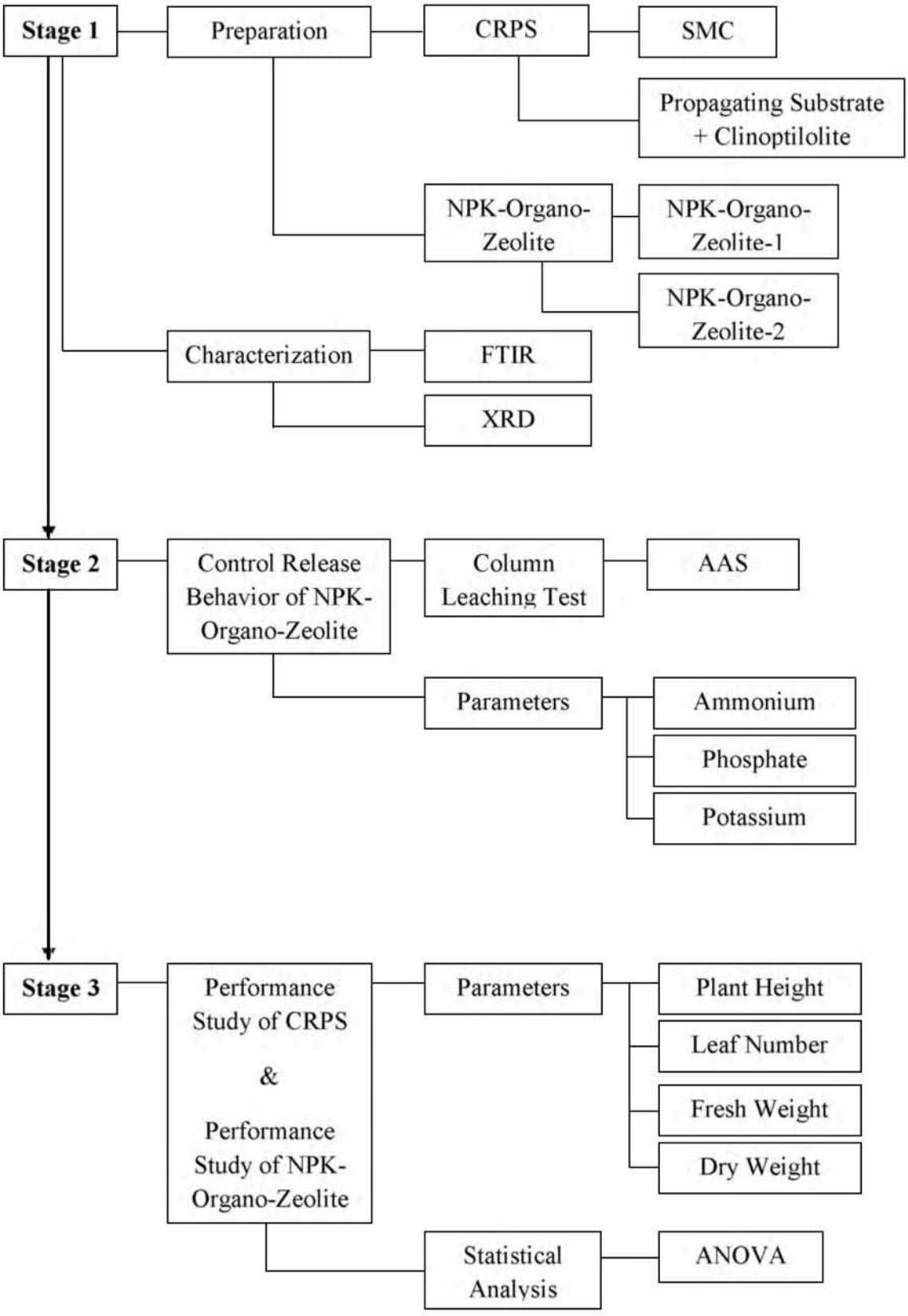

Figure 1.1 Flow diagram of the research design

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