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DEVELOPMENT, BENEFICIAL EFFECTS, AND ECONOMIC VIABILITY OF RICE STRAW AND PADDY HUSK COMPOSTS IN COMBINATION WITH CLINOPTILOLITE ZEOLITE

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By

LATIFAH BT OMAR

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Doctor of Philosophy

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Chairman: Associate Professor Ahmed Osumanu Haruna, PhD
Faculty : Agriculture and Food Sciences (Bintulu)

Indiscriminate uses of nitrogen (N) fertilizers lead to low N use efficiency and losses through runoff, leaching, denitrification, and volatilization resulting in a series of environmental problems. Clinoptilolite zeolite and composts derived from agricultural wastes could be used to improve N use efficiency by adsorbing NH_4^+ ions from urea and desorbing them timely for *Zea mays* L. (test crop) use because the clinoptilolite zeolite, rice straw, and paddy husk composts have high affinity for NH_4^+ ions. Thus, the objectives of this study were to: (i) produce composts through co-composting of rice straw and paddy husk with chicken slurry amended with clinoptilolite zeolite; (ii) improve N availability by retaining exchangeable NH_4^+ through the use of clinoptilolite zeolite, rice straw, and paddy husk composts; (iii) determine the use of clinoptilolite zeolite, rice straw, and paddy husk composts in improving N use efficiency and grain yield of *Zea mays* L. cultivation on a tropical acid soil; and (iv) determine the economic viability of using combination of inorganic fertilizers, clinoptilolite zeolite, rice straw, and paddy husk composts in *Zea mays* L. cultivation on a tropical acid soil. Rice straw compost was produced by mixing 20 kg of rice straw + 1 kg of chicken feed + 1 kg of molasses + 1 kg clinoptilolite zeolite + 1 kg urea + 13 L chicken slurry in five polystyrene boxes and these ratios apply to mixture of paddy husk too. Mature composts with good agronomic properties, dark brown, soft, coarse with friable texture, and earthy smell were produced by co-composting rice straw and paddy husk with chicken slurry and clinoptilolite zeolite as additives. Soil leaching and incubation studies were conducted for 30 and 90 days, respectively, to determine the effects of amending urea with clinoptilolite zeolite, rice straw and paddy husk composts on controlling NH_4^+ and NO_3^- losses from urea. Urea amended with clinoptilolite zeolite, rice straw and paddy husk composts significantly controlled NH_4^+ and NO_3^- release from urea (soil leaching and incubation studies) compared with urea alone, thus reducing leaching of NH_4^+ and NO_3^-. Ammonium and NO_3^- leaching losses during the 30 days of leaching and 90 days of incubation were highest in urea alone compared

with urea amended with clinoptilolite zeolite, rice straw, and paddy husk composts treatments. The higher adsorption and lower desorption of NH_4^+ in soils with clinoptilolite zeolite, rice straw, and paddy husk composts corroborated the ability of clinoptilolite to be used as NH_4^+ adsorbent and rice straw and paddy husk composts as NH_4^+ bio-adsorbent. The high buffering capacities of rice straw and paddy husk composts ensured higher rate of NH_4^+ adsorption. Combined use of urea, clinoptilolite zeolite, rice straw, and paddy husk composts improved soil total N, exchangeable NH_4^+, and available NO_3^- compared with urea alone. Soil total hydrolyzable N, NH_4-N, (NH_4^+ + amino sugar)-N, amino sugar-N, and amino acid-N soils were higher in soils with clinoptilolite zeolite, rice straw, and paddy husk composts compared with urea alone suggesting mineralization of N into available forms of N (NH_4^+ and NO_3^-) was affected by the addition of clinoptilolite zeolite, rice straw, and paddy husk composts. Urea can be amended with clinoptilolite zeolite, rice straw, and paddy husk composts to regulate availability N for optimum crops use. Promising treatments from the soil leaching and incubation studies were tested in a pot study using *Zea mays* L. Thai super sweet hybrid F1 (test crop) under controlled environment. At 45 days after planting (tasseling stage of *Zea mays* L.), amending inorganic fertilizers with clinoptilolite zeolite, rice straw and paddy husk composts increased soil total N, exchangeable Ca, Mg, K, and available P. Uptake and use efficiency of P and K of *Zea mays* L. were significantly improved upon amending inorganic fertilizers with clinoptilolite zeolite, rice straw and paddy husk composts. The treatments in the pot study were further tested in a field trial. A field trial was conducted for 72 days (maturity period of *Zea mays* L.) for two consecutive planting cycles of *Zea mays* L. Amending urea with clinoptilolite zeolite, rice straw, and paddy husk composts improved N use efficiency because of temporary adsorption of exchangeable NH_4^+ on the negative charge sites of the clinoptilolite zeolite and organic matter of the rice straw and paddy husk composts. As a result, N use efficiency and grain yield of *Zea mays* L. were increased. The use of inorganic fertilizers, clinoptilolite zeolite, rice straw, and paddy husk composts also enhanced timely uptake of P, K, Ca, Mg, and Na in the aboveground biomass of *Zea mays* L. compared with the conventional use of inorganic fertilizers alone. The higher retention of N, P, K, Ca, Mg, and Na in the soil regardless of the planting cycle of *Zea mays* L. suggests build-up of these nutrients in the soil. This is partly responsible for the higher fresh cobs yield of the *Zea mays* L. in the plots with inorganic fertilizers, clinoptilolite zeolite, rice straw, and paddy husk composts compared with inorganic fertilizers only. A follow up laboratory study on the field trials was conducted to determine the effects of clinoptilolite zeolite, rice straw, and paddy husk composts on decomposition of soil N fractions. Clinoptilolite zeolite, rice straw, and paddy husk composts increased total hydrolyzable N, NH_4-N, (NH_4^+ + amino sugar)-N, amino sugar-N, and amino acid-N compared with urea alone suggesting the clinoptilolite zeolite, rice straw, and paddy husk composts increased N availability by gradually hydrolyzing NH_4^+ and timely mineralizing NH_4^+ for *Zea mays* L. use. The higher (NH_4^+ + amino sugar)-N, amino sugar-N, and amino acid-N in the soil with clinoptilolite zeolite, rice straw, and paddy husk composts amendment were significantly affected by the higher soil total hydrolyzable N and NH_4-N following application of clinoptilolite zeolite, rice straw, and paddy husk composts. Combined application of inorganic fertilizers, clinoptilolite zeolite, rice straw, and paddy husk composts did not only improved soil total N availability and N use efficiency but it also increased P, K, Ca, Mg, and Na availability, uptake, and use efficiency of these nutrients. Besides, the combination of inorganic fertilizers, clinoptilolite zeolite, rice straw, and paddy husk increased grain yield of *Zea mays* L. Economic assessment study of using clinoptilolite zeolite, rice straw, and paddy husk composts showed higher total costs production of using these amendments in maize cultivation compared with inorganic fertilizers only. The lower total production costs associated with conventional practice with lower gross revenue and net revenue are relates to the use of inorganic fertilizers only. However, higher maize yield, net revenue, and benefit-cost ratio were obtained for the combined use of inorganic fertilizers, clinoptilolite zeolite, rice straw, and paddy husk composts in *Zea mays* L. cultivation and thus, suggest economic viability of including clinoptilolite zeolite, rice straw, and paddy husk composts.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PEMBANGUNAN, KESAN-KESAN BERFAEDAH, DAN DAYA MAJU EKONOMI DARI KOMPOS JERAMI PADI DAN SEKAM PADI DENGAN GABUNGAN KLINOPTILOLIT ZEOLIT

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Penggunaan nitrogen (N) sembarangan menyebabkan kecekapan penggunaan N yang rendah dan hilang melalui air larian, larut resap, pedenitratan, dan pemeruapan menghasilkan siri-siri masalah alam sekitar. Klinoptilolit zeolit dan kompos dihasilkan dari sisa pertanian kemungkinan boleh digunakan untuk meningkatkan kecekapan penggunaan N dengan menjerap ion-ion ammonium dari urea dan melepaskannya mengikut masa untuk kegunaan jagung (tanaman kajian) sebab klinoptil zeolit, kompos jerami padi, dan kompos sekam padi mempunyai tarikan tinggi terhadap ion-ion ammonium. Dengan itu, objektif kajian ini adalah untuk: (i) menghasilkan kompos melalui pengkomposan bersama jerami padi dan sekam padi dengan cairan tinja ayam yang ditambahbaik dengan klinoptilolit zeolit; (ii) meningkatkan keterdapatan N dengan mengekalkan pertukaran ammonium melalui penggunaan klinoptilolit zeolit, kompos jerami padi, dan kompos sekam padi; (iii) menentukan penggunaan klinoptilolit zeolit, kompos jerami padi, dan kompos sekam padi dalam meningkatkan kecekapan penggunaan N dan hasil bijirin jagung dalam penanaman jagung di tanah asid tropika; dan (iv) menentukan daya maju ekonomi menggunakan gabungan baja bukan organik, klinoptilolit zeolit, kompos jerami padi, dan kompos sekam padi dalam penanaman jagung di tanah asid tropika. Kompos jerami padi dihasilkan dengan mencampur 20 kg jerami padi + 1 kg makanan ayam + 1 kg gula perang + 1 kg klinoptilolit zeolit + 1 kg urea + 13 L cairan tinja ayam dalam 5 kotak polisterin dan nisbah yang sama dilakukan untuk mencampurkan sekam padi. Kompos yang matang dengan kandungan pertanian yang baik, perang gelap, lembut, tekstur peroi dan gembur, dan berbau tanah telah dihasilkan melalui pengkomposan bersama jerami padi dan sekam padi dengan cairan tinja ayam dan klinoptilolit zeolit sebagai bahan tambahan. Kajian tanah larut resap dan inkubasi dijalankan selama 30 hari dan 90 hari, masing-masing untuk menentukan kesan-kesan menambahbaik urea dengan klinoptilolit zeolit, kompos jerami padi, dan kompos sekam padi untuk mengawal kehilangan NH_4^+ and NO_3^- dari urea. Urea ditambahbaik dengan klinoptil zeolit,

kompos jerami padi dan kompos sekam padi secara nyata mengurangkan pembebasan NH_4^+ and NO_3^- dari urea (kajian-kajian larut resap tanah dan inkubasi tanah) dibandingkan dengan urea sahaja, dengan itu telah mengurangkan larut resap NH_4^+ dan NO_3^-. Kehilangan NH_4^+ and NO_3^- dalam 30 hari kajian tanah larut resap dan 90 hari kajian inkubasi tanah paling tinggi dalam urea sahaja dibandingkan dengan rawatan urea yang ditambahbaik dengan klinoptilolit zeolit, kompos jerami padi, dan kompos sekam padi. Penjerapan NH_4^+ yang tinggi dan pembebasan NH_4^+ yang rendah dalam tanah dengan klinoptilolit zeolit, kompos jerami padi, dan kompos sekam padi menyokong kebolehan klinoptilolit zeolit untuk diguna sebagai penjerap dan kompos jerami padi dan kompos sekam padi sebagai bio-penjerap. Daya penampan yang tinggi pada kompos jerami padi dan kompos sekam padi memastikan kadar penjerapan NH_4^+ yang tinggi. Gabungan penggunaan urea, klinoptilolit zeolit, kompos jerami padi, dan kompos sekam padi meningkatkan jumlah tanah N, pertukaran NH_4^+, keterdapatan NO_3^- berbanding dengan urea sahaja. Jumlah tanah hidrolizabel N, NH_4-N, (NH_4^+ + gula amino)-N, gula amino-N, and asid amino-N adalah tinggi dalam tanah dengan klinoptilolit zeolit, kompos jerami padi, dan kompos sekam padi berbanding dengan urea sahaja menunjukkan penguraian pecahan N kepada bentuk galian N yang tersedia (NH_4^+ and NO_3^-) adalah kesan daripada penambahan klinoptilolit zeolit, kompos jerami padi, dan kompos sekam padi. Urea boleh ditambahbaik dengan klinoptilolit zeolit, kompos jerami padi, dan kompos sekam padi untuk mengawal keterdapatan N untuk kegunaan tanaman yang optima. Rawatan-rawatan yang mempunyai harapan daripada kajian-kajian larut resap dan inkubasi tanah telah diuji dalam kajian pasu menggunakan jagung varieti Thai jagung manis hibrid F1 (tanaman kajian) dalam keadaan persekitaran terkawal. Pada 45 hari (pembentukan jambak bunga jagung), penambahbaikan baja-baja bukan organik dengan klinoptilolit zeolit, kompos jerami padi, dan kompos sekam padi meningkatkan jumlah N tanah, pertukaran Ca, Mg, K, dan keterdapatan P. Pengambilan dan kecekapan penggunaan P dan K dalam penanaman jagung secara nyata meningkat apabila baja-baja bukan organic ditambahbaik dengan klinoptilolit zeolit, kompos jerami padi dan kompos sekam padi. Rawatan-rawatan dari kajian pasu telah dilanjutkan ujian dalam kajian tanaman di lapangan. Kajian percubaan lapangan telah dijalankan selama 72 hari (tempoh kematangan jagung) bagi dua pusingan tanaman berturutan. Penambahbaikan urea dengan klinotilolit zeolit, kompos jerami padi dan kompos sekam padi meningkatkan kecekapan penggunaan N disebabkan penjerapan sementara pertukaran NH_4^+ di atas caj negatif pada tapak-tapak pertukaran klinoptilolit zeolit dan bahan organik dalam kompos jerami padi dan kompos sekam padi. Hasilnya, kecekapan penggunaan N dan hasil bijian jagung telah meningkat. Penggunaan baja bukan organik, klinoptilolit zeolit, kompos jerami padi, dan kompos sekam padi telah meningkatkan pengambilan P, K, Ca, Mg, dan Na dalam biojisim jagung atas tanah dibandingkan dengan penggunaan konvensional baja bukan organik sahaja. Pengekalan N, P, K, Ca, Mg, dan Na yang tinggi dalam tanah tanpa mengira pusingan tanaman jagung menunjukkan pembinaan nutrien-nutrien ini dalam tanah. Ini sebahagiannya bertanggungjawab dalam hasil bijian jagung yang tinggi dalam plot-plot dengan pembajaan bukan organik, klinoptilolit zeolit, kompos jerami padi, dan kompos sekam padi dibandingkan dengan pembajaan bukan organik sahaja. Kajian susulan daripada percubaan lapangan telah dijalankan untuk menentukan kesan-kesan klinoptilolit zeolit, kompos jerami padi, dan kompos sekam padi ke atas penguraian pecahan-pecahan N dalam tanah. Klinoptilolit zeolit, kompos jerami padi, dan kompos sekam padi meningkatkan jumlah hidrolizabel N, NH_4-N, (NH_4^+ + gula amino)-N, gula amino-N, and asid amino-N berbanding baja bukan organik sahaja menunjukkan klinoptilolit zeolit, kompos jerami padi, dan kompos sekam padi meningkatkan keterdapatan N melalui hidrolisis N secara perlahan dan pelepasan N mengikut masa untuk kegunaan pertumbuhan jagung. Jumlah kandungan hidrolizabel N, NH_4-N, (NH_4^+ + gula amino)-N, gula amino-N, and asid amino-N yang tinggi dalam tanah dengan penambahbaik klinoptilolit zeolit, kompos jerami padi, dan kompos sekam padi secara nyata dipengaruhi oleh jumlah hidrolizabel N dan NH_4-N yang tinggi berikutan daripada penggunaan klinoptilolit zeolit, kompos jerami padi, dan kompos sekam padi. Gabungan penggunaan baja bukan organik, klinoptilolit zeolit, kompos jerami padi, dan kompos sekam padi bukan sahaja meningkatkan keterdapatan jumlah N tanah dan kecekapan penggunaan N tetapi juga meningkatkan keterdapatan P, K, Ca, Mg, dan Na dan kecekapan penggunaan nutrien-nutrien tersebut. Selain daripada itu, gabungan baja bukan organik, klinoptilolit zeolit, kompos jerami padi, dan kompos sekam padi meningkatkan hasil bijian jagung. Kajian penilaian ekonomi dalam penggunaan klinoptilolit zeolit, kompos jerami padi, dan kompos sekam padi menunjukkan kos pengeluaran yang tinggi dalam penanaman jagung berbanding pengunaan baja bukan organik sahaja. Jumlah kos pengeluaran yang rendah dengan amalan konvensional dengan pendapatan kasar dan pendapatan bersih yang rendah adalah berkaitan dengan penggunaan baja bukan organik sahaja. Walau bagaimanapun, hasil jagung yang tinggi, pendapatan bersih, dan kadar kos faedah telah dicapai dengan penggunaan gabungan baja bukan organik, klinoptilolit zeolit, kompos jerami padi, dan kompos sekam padi dalam penanaman jagung, dengan itu, menunjukkan ekonomi berdaya maju dengan menggunakan klinoptilolit zeolit, kompos jerami padi, dan kompos sekam padi.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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AAS	Atomic absorption spectrophotometer
CEC	Cation Exchange Capacity
CRD	Complete randomized design
MOP	Muriate of potash
NBPT	N-(n-butyl) thiophosphoric triamide
NUE	Nitrogen use efficiency
OM	Organic matter
ppm	part per million
RCBD	Randomized complete block design
SAS	Statistical analysis system
TSP	Triple superphosphate

CHAPTER 1

INTRODUCTION

1.1 Background and Problem Statement

Soil nitrogen (N) is an essential element that is required for crops growth. It exists primarily in organic forms that are not accessible for crop uptake (Brady and Weil, 2010; Mosier *et al*., 2004). According to Draycott and Christensen (2003), organic N in soil organic matter is converted to crop-usable inorganic forms through mineralization mediated by soil microorganism activities. However, the readily available N could exceed crop such that it leads to N losses (Myers *et al.* 1994). Nitrogen can be lost in soil-crop system because of NH_3 volatilization (Ahmed *et al*., 2010; Latifah *et al.*, 2010), denitrification, leaching, and surface runoff (Brady and Weil, 2010). If soil N supply is greater than crop demand, loss of N through leaching of nitrate (NO_3^-) eventually pollutes ground or surface water. Improper use of N fertilizers leads to numerous environmental problems such as soil acidification and eutrophication of coastal systems (Crutzen *et al*., 2008; Boyer and Howarth, 2002).

To increase crop productivity and yield, N fertilizers are used in large amounts with only a small fraction of these fertilizers (5 to 50%) taken up by crops (Carranca, 2012). Applied N that is not taken up by crops or immobilized in soils are prone to loss through volatilization, denitrification, leaching, and runoff eventually cause serious environmental problems (Canfield *et al*., 2010) besides reducing N use efficiency (Hatfield and Prueger, 2004). Nitrogen use efficiency (NUE) is important for improving crop productivity and yield. If NUE is not improved, marginal lands, including those on steep slopes will be cultivated to help meet the ever increasing demand for food. This could result in land degradation. Because of the limitation on arable land and the need to minimize water and air pollution, efficient use of N fertilizers to sustain land quality and also to meet the ever increasing growing population cannot be over-emphasized (Cassman *et al.*, 2002). In the increasingly polluted environment and increasing energy consumption, it is crucial to increase NUE by using existing resources such as agricultural wastes as wastes management practices and advanced technologies in composts production lead to optimized land use and increase in crop yield.

The current practice in agriculture is chemical based farming that makes considerable degradation of natural resources, particularly soils (Priyadharsini and Seran, 2009). As a result, various approaches have been tried on the use of available and renewable resources of crop nutrients for complementing and supplementing commercial fertilizers. Efforts are on-going to systematically evaluate the feasibility and efficacy of organic residues, not only for refurbishing soil productivity but to also promote efficient use of chemical fertilizers (Ariyaratne, 2000). The high costs of inorganic fertilizers have necessitated best-developed practices designed to optimize fertilizers use and to as well minimize nutrients losses. An example is the combined use of organic and inorganic fertilizers in crop production as a way of increasing yield and soil productivity (Mamaril *et al*., 1999). Soil organic amendments such as composts can be used to enhance soil productivity by providing soil organic matter and biological cycle of nutrients that are essential for successful management of acid soils. Trujillo (2002) opined that the use of composts in agriculture does not only enhance retention of nutrients in chemical fertilizers but it also supplies nutrients to crops besides supporting rapid nutrients cycling (through microbial biomass).

To develop new techniques that could put wastes into good use is one of the challenges in agro-industrial wastes management in Malaysia (Ch'ng *et al.*, 2015). Malaysia is not a prominent rice-producing country but large quantities of rice wastes are produced every growing season in this country (Department of Agriculture Malaysia, 2012). In Malaysia, there are 684,000 ha of paddy fields from which 1.3 million tonnes (t) of rice straw are produced every year (MARDI, 2010). According to Lim *et al.* (2012), for every kg of harvested rice, paddy husk accounts for between 20 and 30% of paddy weight. The annual global quantity of paddy husk generated is 137 million t (Lim *et al*., 2012). Apart from rice wastes, wastes generated in poultry farms are increasing as the poultry industry grows. As the third largest producer of chicken products in Asia, chicken manure disposal is becoming a challenge in Malaysia. In 2012, 674 million and 637 million day-old chicks and broilers respectively, were produced (Market Watch Report, 2012). The daily manure production by a laying hen has been estimated as 138 g day^{-1} (25% dry substance) and 90 g day^{-1} (40% dry substance) by a broiler. The use of chicken farm wastes as a fertilizer is common (Burton and Turner, 2003). However, direct application of chicken manure as a fertilizer may cause environmental problems such as foul odour, eutrophication, and a breeding ground for pests and diseases (Arifin *et al.*, 2006). Co-composting these wastes (rice straw, paddy husk, and chicken manure) to produce organic amendments such as compost is essential.

Co-composting of agricultural wastes such as rice straw, paddy husk, clinoptilolite zeolite, and chicken slurry may help to improve NUE of N based fertilizers in agriculture. Rice straw and paddy husk are resistant to microbial decomposition because of their high carbon to nitrogen (C/N) ratio and high content of ligno-cellulose (Zhu *et al*., 2000). Composts derived from co-composting of rice straw or paddy husk with chicken manure can be used as a valuable soil amendment with many benefits to agricultural systems. However, N loss during co-composting can be substantial and this loss may cause air pollution. Besides it will as well reduce the nutritive value of composts. According to Witter and Kirchmann (1989), N transformations in the first stage of composting of N-rich material are generally characterized by high rates of ammonification.

The greatest N losses during composting are caused by gaseous emissions in the form of ammonia (NH_3). High losses of ammonium (NH_4^+) do not only reduce the agronomic value of the end-product but they also contribute to environmental pollution (Witter and Kirchmann, 1989). Therefore, co-composting of rice straw or paddy husk with chicken slurry and clinoptilolite zeolite is likely to provide better results such as killing of pathogens, converting NH_3 to NH_4^+, reducing the wastes volume, and as well as serving as soil amendment for agriculture (Zhu *et al*., 2000). The use of clinoptilolite zeolite in co-composting of rice straw or paddy husk with chicken slurry may reduce leaching of N and NH_3 volatilization because NH_4^+ is absorbed by clinoptilolite zeolite partly due to the high affinity of this mineral for NH_4^+ (Kithome *et al.*, 1998). Zeolites have been widely used in agriculture to capture and release N (Ramesh *et al.*, 2010). The NH_4^+ adsorption properties of zeolites enable them to be used as NH_4^+ and/or NH_3 adsorbents during composting (Bernal *et al.*, 1993) whereas their ability to desorb adsorbed NH_4^+ could be explored so as to use them to regulate the release of NH_4^+ from N based fertilizers and manures such as poultry manure.

The manure-NH_4^+ sequestered in clinoptilolite zeolite is unavailable to nitrifying bacteria because of the small pore size of the crystal lattice structure (Mumpton, 1999). Although zeolites have been widely used in agriculture to capture and release N, there is lack of information about the effectiveness of using clinoptilolite zeolite in co-composting of agricultural wastes such as rice straw and paddy husk with chicken slurry. Despite the fact that composts are often used to improve soil structure and as well as to increase the content of soil organic matter, the effects of composts on improving N availability by retaining exchangeable NH_4^+ and available NO_3^- are scarcely explored.

1.2 Objectives

The objectives of this study were to produce organic amendments through co-composting of rice straw and paddy husk with chicken slurry amended with clinoptilolite zeolite as an additive. With these organic amendments, the following were further determined:

1. Nitrogen availability and N use efficiency
2. Grain yield of *Zea mays* L.
3. Economic viability

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BIODATA OF STUDENT

Latifah Binti Omar originated from Dalat, Sarawak. She received her primary education from Sekolah Kebangsaan Sungai Ud Dalat, Sarawak. After completing her secondary school education at Sekolah Menengah Kerajaan Rosli Dhoby Sibu, Sarawak, she worked at Sekolah Menengah Kerajaan Three River Mukah Sarawak as a temporary teacher. She was registered as a full time diploma student at Universiti Putra Malaysia Bintulu Sarawak Campus and awarded a diploma in agriculture in 2005. Latifah pursued her undergraduate first degree at UPM Bintulu Sarawak Campus from 2005 to 2009 where she was awarded Bachelor Science in Bioindustry. In June 2009, she enrolled as a full time master's student at Universiti Putra Malaysia Bintulu Sarawak Campus. She had presented an oral paper at 1st Graduate Science Student Research Conference 2010 in Universiti Brunei Darussalam, Brunei Darussalam. She was awarded Master of Science (Agronomy) in 2011. Currently, she is a Doctor of Philosophy (Agronomy) in Universiti Putra Malaysia Bintulu Sarawak Campus. She attended national conference 2nd International Symposium on Tropical Forest Ecosystem Science and Management: Challenges and Solution, 2013 organized by Universiti Putra Malaysia Bintulu Sarawak Campus and Soil Science Conference of Malaysia 2014 on 8 – 10 April, 2014 in Hotel Putra Palace, Kangar, Perlis, Malaysia. She won excellent poster presentation in Soil Science Conference of Malaysia 2014, Hotel Putra Palace, Kangar, Perlis, Malaysia. She also attended international conference at The International Bioscience Conference 2014 and the 5th Joint PSU-UNS International Bioscience Conference, Phuket, Thailand which held on 29 – 30 September, 2014.

LISTS OF PUBLICATIONS

(a) Papers Published or Submitted

1. Latifah Omar, Osumanu Haruna Ahmed, Nik Muhamad Nik Abdul Majid, and Susilawati Kasim. 2015. Compost maturity and nitrogen availability by co- composting of paddy husk and chicken manure amended with clinoptilolite zeolite. Waste Management and Research Vol. 33(4): 322 – 331.

2. Latifah Omar, Osumanu Haruna Ahmed, and Nik Muhamad Nik Abdul Majid. 2015. Improving ammonium and nitrate release from urea using clinoptilolite zeolite and compost produced from agricultural wastes. The Scientific World Journal 574201 (2015):1 – 12.

3. Latifah Omar, Osumanu Haruna Ahmed, and Nik Muhamad Nik Abdul Majid. 2016. Effect of organic amendment derived from co-composting of chicken slurry and rice straw on reducing nitrogen loss from urea. Communication in Soil Science and Plant Analysis. 47(5) 639 – 656.

4. Latifah Omar, Osumanu Haruna Ahmed, and Nik Muhamad Nik Abdul Majid. Short Term Enhancement of Nutrients Availability in *Zea mays* L. Cultivation on an Acid Soil using Compost and Clinoptilolite Zeolite. Compost Science and Utilization. DOI:10.1080/1065657X.2016.1172054.

5. Latifah Omar, Osumanu Haruna Ahmed, and Nik Muhamad Nik Abdul Majid. Amending chemical fertilizers with compost and clinoptilolite zeolite and their effects on nitrogen use efficiency and fresh cob yield of *Zea mays* L. Communications in Soil and Plant Analysis (Awaiting for decision).

6. Latifah Omar, Osumanu Haruna Ahmed, and Nik Muhamad Nik Abdul Majid Enhancing Nitrogen Use Efficiency and Yield of *Zea mays* L. Cultivated on a Tropical Acid Soil using Paddy Husk Compost and Clinoptilolite Zeolite. Soil Science and Plant Nutrition (Awaiting for decision).

7. Latifah Omar, Osumanu Haruna Ahmed, and Nik Muhamad Nik Abdul Majid. Controlling ammonium and nitrate leaching loss from urea using paddy husk compost and clinoptilolite zeolite. Philipine Agriculture Scientist (Awaiting for decision).

8. Latifah Omar, Osumanu Haruna Ahmed, and Nik Muhamad Nik Abdul Majid. Improving nutrient uptake and use efficiency of maize (*Zea mays* L.) cultivated on a tropical acid soil using paddy husk compost and clinoptilolite zeolite. Sustainable Agriculture Research (Awaiting for decision).

(b) Presented Works

1. Latifah Omar, Osumanu Haruna Ahmed, Nik Muhamad Nik Abdul Majid, and Susilawati Kasim. 2014. Use of clinoptilolite zeolite to mitigate nitrogen loss during co-composting of paddy husk and chicken manure. Soil Science Conference of Malaysia 2014. Hotel Putra Palace, Kangar, Perlis, Malaysia. 8 – 10 April, 2014.

2. Latifah Omar, Osumanu Haruna Ahmed, and Nik Muhamad Nik Abdul Majid. Reducing nitrogen leaching loss through the use of clinoptilolite zeolite and compost from rice straw and chicken manure. Presented at The International Bioscience Conference 2014 and the 5th Joint PSU-UNS International Bioscience Conference, Phuket, Thailand. 29 – 30 September, 2014.

(c) Papers to be submitted

1. Latifah Omar, Osumanu Haruna Ahmed, and Nik Muhamad Nik Abdul Majid. Availability of soil nitrogen fractions following urea, clinoptilolite zeolite, and rice straw compost.

2. Latifah Omar, Osumanu Haruna Ahmed, and Nik Muhamad Nik Abdul Majid. Effect of clinoptilolite zeolite and paddy husk composts on soil nitrogen fractionations from urea.

3. Latifah Omar, Osumanu Haruna Ahmed, and Nik Muhamad Nik Abdul Majid. Economic viability of using clinoptilolite zeolite and rice straw compost in *Zea mays* L. cultivation.

4. Latifah Omar, Osumanu Haruna Ahmed, and Nik Muhamad Nik Abdul Majid. Economic assessment of including clinoptilolite zeolite and paddy husk compost in *Zea mays* L. cultivation.

LIST OF AWARDS

1. Excellent Poster Presentation Award, "Use of Clinoptilolite Zeolite to Mitigate Nitrogen Loss during Co-Composting of Paddy Husk and Chicken Manure". Soil Science Conference of Malaysia 2014 on 8 – 10 April, 2014. Hotel Putra Palace, Kangar, Perlis, Malaysia.

2. Silver medal, "Biological agriculture to improve crops productivity without polluting the environment". Invention and Innovation Awards 2016. Malaysia Technology Expo 2016 on 18 – 20 February 2016. Putra World Trade Centre, Kuala Lumpur.