



**UNIVERSITI PUTRA MALAYSIA**

***EFFECTS OF IMO-COMPOST ON GROWTH OF MAIZE (ZEA MAYS L.)***

**NORIDA HANIM AWING**

**FPSM 2014 1**



**EFFECTS OF IMO-COMPOST ON GROWTH OF MAIZE (*ZEA MAYS L.*)**

By

**NORIDA HANIM BINTI AWING**

**Thesis Submitted to the School of Graduate Studies,  
Universiti Putra Malaysia, in Fulfilment of the  
Requirements for the Degree of Master of Science**

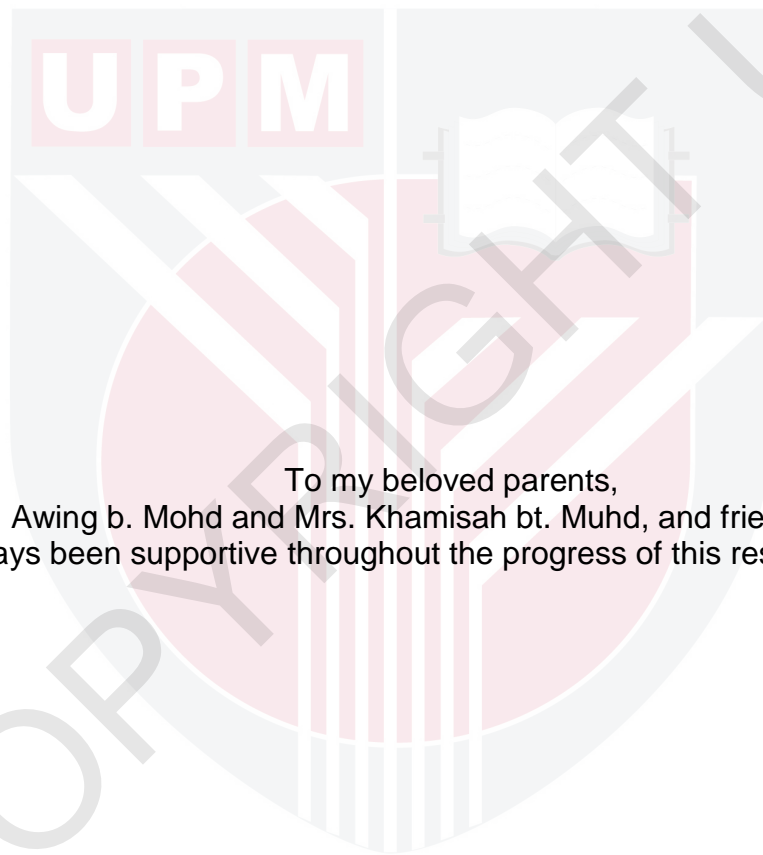
**February 2014**

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To my beloved parents,  
Mr. Awing b. Mohd and Mrs. Khamisah bt. Muhd, and friends who had  
always been supportive throughout the progress of this research project



Abstract of thesis presented to the Senate of Universiti Putra Malaysia  
In fulfilment of the requirement for the degree of Master of Science

## EFFECTS OF IMO-COMPOST ON GROWTH OF MAIZE (*ZEA MAYS L.*)

By

**NORIDA HANIM BINTI AWING**

**February 2014**

**Chairman : Dato' Nik Muhamad bin Nik Ab. Majid, PhD.**  
**Faculty : Agriculture and Food Science (Bintulu)**

Paddy husk (PH) and corn stalk (CS) residues are usually disposed through open burning. Compost could instead be produced from these residues. Composting is the conversion of organic residues into useful organic soil amendments that provide nutrients to crops and enhance the tilth, fertility, and productivity of soils. However, some composting methods are not effective in producing good quality compost. Therefore, this study was conducted to develop an effective way of utilising these residues by composting with indigenous microorganisms (IMO). Inoculated bacteria from steamed white rice (SWR), aerated fish pond water (AFPW), and kitchen wastes (KW) were used. Composting was conducted in a white polystyrene box measuring 30 x 15 x 25 cm and attained an ambient temperature of 25.8°C for 34 days. The composts were analyzed for C/N and C/P ratios, pH (H<sub>2</sub>O and KCl), nutrient content, organic carbon, organic matter, ash, Cation Exchange Capacity (CEC), humic acid (HAs), acidic functional groups, E<sub>4</sub>/E<sub>6</sub> ratio, spectral, and microbial count. IMO-composts were blackish in colour without foul odours which indicate the stable nature of the composts. IMO-compost from corn stalk residues using aerated fish pond water (AFPW) inoculants showed higher positive relationship of HA with total N, P, K, C/N and C/P ratio, pH, TOC, OM, and CEC compared to the other treatments. Identifying bacterial through FAME analysis for three different IMO sources, SWR, AFPW and KW showed the following five beneficial bacteria; *Bacillus cereus* from SWR, AFPW and KW, *Bacillus sphaericus* from KW, *Bacillus megaterium* from SWR, *Acinetobacter calcoaceticus* from KW and *Microbacterium barkeri* from AFPW. IMO-composts were further tested in a pot experiment (shelter rain house) whereby Sweet Corn (D56) variety of maize (*Zea mays L.*) was used as the test crop to evaluate the effect of IMO-compost on nutrient use efficiency by maize. The treatments evaluated were: (T0) no fertilization, (T1) N, P and K (4.84g urea + 2.48g muriate of potast (MOP) + 4.91g triple super phosphate (TSP)), (T2) 77.96g IMO(V)-compost<sub>(SWR-PH)</sub> + 0.72g MOP + 1.41g TSP, (T3) 74.54g IMO(V)-compost<sub>(SWR-CS)</sub> + 0.00g MOP + 0.64g TSP, (T4) 57.90g IMO(V)-compost<sub>(AFPW-PH)</sub> + 0.29g MOP + 2.35g TSP, (T5) 38.72g IMO(V)-compost<sub>(AFPW-CS)</sub> + 0.15g MOP + 2.48g TSP, (T6) 59.49g IMO(V)-compost<sub>(KW-PH)</sub> + 0.28g MOP + 2.32g TSP, and (T7) 51.41g IMO(V)-

compost<sub>(KW-CS)</sub> + 0.04g MOP + 2.01g TSP. Application of chemical fertilizer was done on 10<sup>th</sup> and 28<sup>th</sup> day after sowing (DAS). Sandy clay loam Typic Tualemkuts (Bekenu Series) was used as the growth medium. The plants were harvested on the 50<sup>th</sup> day after sowing (DAS) during tassel stage. The plant parts (leaves, stems, and roots) were analyzed for N, P, and K and soil samples were analyzed for exchangeable K, Ca, Mg, and Na, CEC, organic matter, organic carbon, total N, available P and pH. Analysis of variance was used to detect treatment effect while Tukey's test was used to compare treatment means. Application of IMO-compost affected soil pH, exchangeable cations, CEC, organic carbon, OM and available P compared to the control treatment (T0). The IMO-compost had no significant effect on total N. IMO-compost (steamed white rice (SWR) inoculants), (T3) had significant effect on dry weight production, while IMO-compost (aerated fish pond water (AFPW) inoculants), T5 had significant effect on N, P and K contents, their uptake, as well as their use efficiency by maize. This method was able to significantly reduce N, P and K application. It can be concluded that mature compost from corn stalk (CS) residue with aerated fish pond water (AFPW) inoculants contained more nutrients, high use efficiency by maize indicating it as a suitable organic soil amendment.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia  
Sebagai memenuhi keperluan untuk ijazah Master Sains

## **KESAN IMO-KOMPOS PADA PERTUMBUHAN JAGUNG (*ZEA MAYS L.*)**

Oleh

**NORIDA HANIM BINTI AWING**

**Februari 2014**

**Pengerusi : Dato' Nik Muhamad bin Nik Ab. Majid, PhD.**  
**Fakulti : Pertanian dan Sains Makanan (Bintulu)**

Sekam padi (PH) dan sisa jagung (CS) dilupuskan melalui pembakaran terbuka. Kompos boleh dihasilkan daripada sisa-sisa ini. Pengkomposan adalah untuk menukarkan sisa-sisa organik kepada pindaan organik tanah yang berguna dalam membekalkan nutrien kepada tanaman serta meningkatkan kegemburan, kesuburan, dan produktiviti tanah. Walau bagaimanapun, beberapa kaedah pengkomposan tidak berkesan dalam menghasilkan kompos yang berkualiti. Oleh yang demikian, kajian ini dijalankan untuk membangunkan cara yang berkesan dalam utilisasi sisa-sisa ini melalui pengkomposan menggunakan inokulasi mikroorganisma asli (IMO). Inokulasi bakteria diperolehi dari sumber-sumber berlainan; nasi kukus (SWR), air kolam ikan (AFPW), dan sisa-sisa dapur (KW). Pengkomposan dijalankan di dalam kotak polisterin putih berukuran 30 x 15 x 5 cm dan mencapai suhu persekitaran 25.8°C pada hari ke-34. Kompos dianalisis untuk nisbah C/N dan C/P, pH (H<sub>2</sub>O dan KCl), kandungan nutrien, karbon organik, bahan organik, abu, kapasiti pertukaran kation (CEC), asid humik (HAs), kumpulan berfungsi berasid, nisbah E<sub>4</sub>/E<sub>6</sub>, spektrum, dan pengiraan. IMO-kompos berwarna kehitaman tanpa bau menunjukkan sifat kompos yang stabil. IMO-kompos daripada sisa jagung yang menggunakan inokulasi air kolam ikan (AFPW) menunjukkan hubungan positif HAs dengan jumlah N, P, K, nisbah C/N dan C/P, pH, TOC, OM, dan CEC berbanding rawatan yang lain. Pengenalpastian bakteria melalui analisis FAME dari tiga sumber IMO yang berbeza, SWR, AFPW dan KW menunjukkan lima bakteria yang berfungsi; *Bacillus cereus* dari sumber SWR, AFPW dan KW, *Bacillus sphaericus* dari KW, *Bacillus megaterium* dari SWR, *Acinetobacter calcoaceticus* dari KW and *Microbacterium barkeri* dari AFPW. IMO-kompos terus diuji bagi eksperimen penanaman di dalam pasu (di bawah rumah kalis hujan) dimana jagung dari varieti Jagung Manis (D56) (*Zea mays L.*) digunakan sebagai tanaman ujian untuk menilai kesan IMO-kompos dalam kecekapan penggunaan nutrien. Rawatan yang dinilai adalah: (T0) tanpa pembajaan, (T1) N, P dan K (4.84g urea + 2.48g muriate of potast (MOP) + 4.91g triple super phosphate (TSP)), (T2) 77.96g IMO(V)-kompos<sub>(SWR-PH)</sub> + 0.72g MOP + 1.41g TSP, (T3) 74.54g IMO(V)-kompos<sub>(SWR-CS)</sub> + 0.00g MOP + 0.64g TSP, (T4) 57.90g IMO(V)-kompos<sub>(AFPW-PH)</sub> + 0.29g MOP + 2.35g TSP, (T5) 38.72g IMO(V)-kompos<sub>(AFPW-CS)</sub> + 0.15g MOP + 2.48g TSP, (T6)

59.49g IMO(V)-kompos<sub>(KW-PH)</sub> + 0.28g MOP + 2.32g TSP, dan (T7) 51.41g IMO(V)-kompos<sub>(KW-CS)</sub> + 0.04g MOP + 2.01g TSP. Pemberian baja kimia dilakukan sebanyak dua kali iaitu pada hari ke-10 dan ke-28 selepas penyemaian (DAS). Tanah jenis berpasir liat lempung dari Tipik Tualemkuts (Siri Bekenu) digunakan sebagai media pertumbuhan. Jagung dituai pada hari ke-50 selepas penyemaian (DAS) semasa peringkat pembungaan jantan. Bahagian-bahagian pokok (daun, batang dan akar) dianalisis untuk N, P dan K dan sampel tanah dianalisis untuk penukaran K, Ca, Mg, dan Na, CEC, bahan organik, karbon organik, jumlah N, P tersedia dan pH. Analisis varians digunakan untuk membezakan kesan terhadap rawatan manakala ujian Tukey telah digunakan bagi membandingkan kebekersanan rawatan. Penggunaan IMO-kompos memberi kesan pada pH tanah, pertukaran kation, CEC, karbon organik, OM dan P tersedia berbanding dengan rawatan kawalan (T0). IMO-kompos tidak menunjukkan kesan yang ketara ke atas jumlah N. IMO-kompos (menggunakan inokulasi nasi kukus (SWR)) (T3), mempunyai kesan yang ketara ke atas berat kering, manakala IMO-kompos (inokulasi air kolam ikan (AFPW)) (T5), mempunyai kesan yang ketara terhadap kandungan, pengambilan serta kecekapan penggunaan N, P, dan K oleh tanaman jagung. Kaedah ini dengan ketara dapat mengurangkan penggunaan baja N, P dan K. Dapat disimpulkan bahawa kompos dari sisa jagung (CS) menggunakan inokulasi dari air kolam ikan (AFPW) mengandungi lebih nutrien serta kecekapan penggunaan yang tinggi oleh pertumbuhan jagung sebagai pindaan organik tanah yang sesuai.

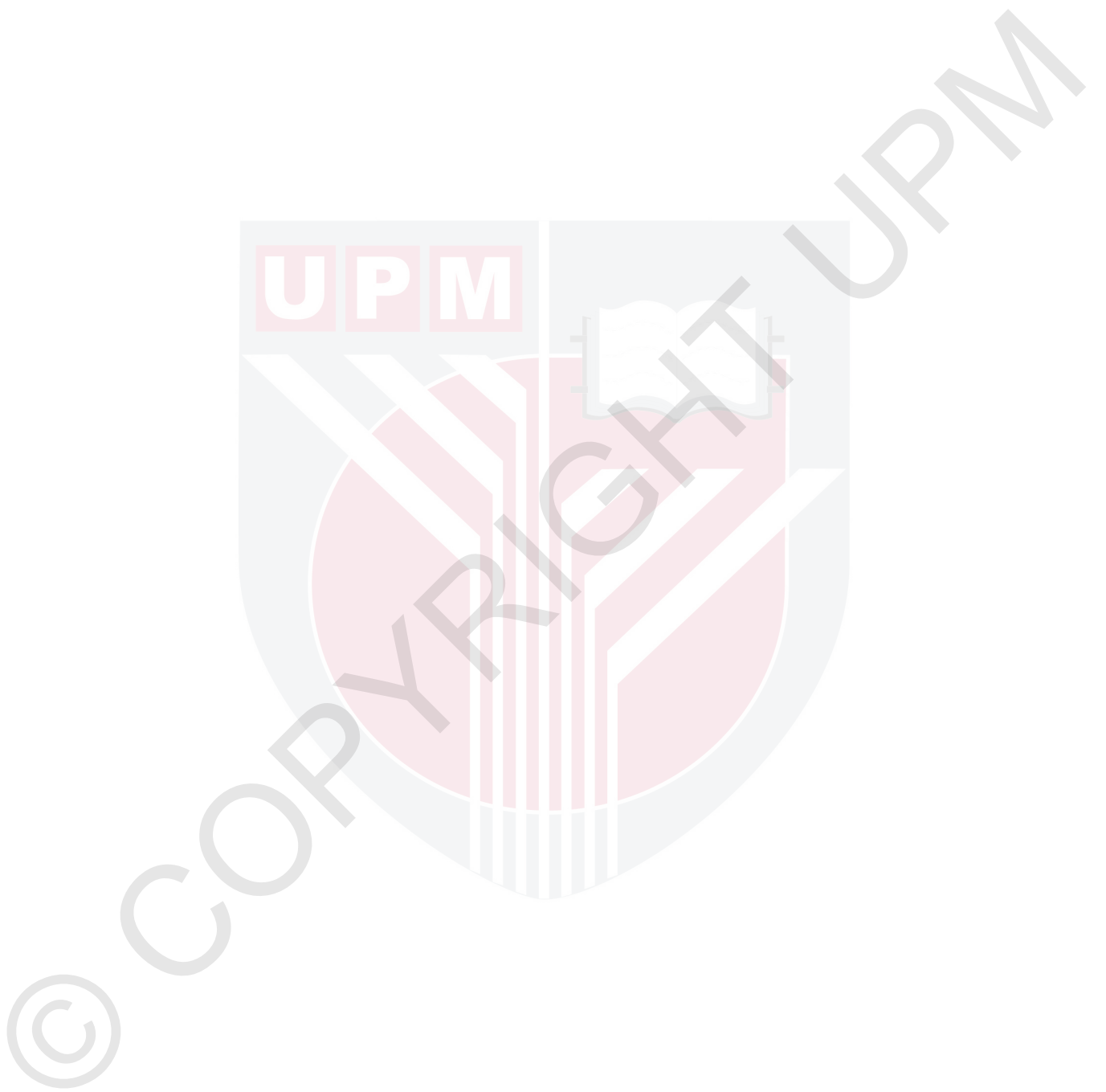


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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

**Dato' Nik Muhamad Bin Nik Ab. Majid, PhD**

Professor

Faculty of Agriculture and Food Sciences

Universiti Putra Malaysia Bintulu Sarawak Campus

(Chairman)

**Ahmed Osumanu Haruna, PhD**

Associate Professor

Faculty of Agriculture and Food Sciences

Universiti Putra Malaysia Bintulu Sarawak Campus

.....  
**BUJANG BIN KIM HUAT, PhD**

Professor and Dean

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Universiti Putra Malaysia

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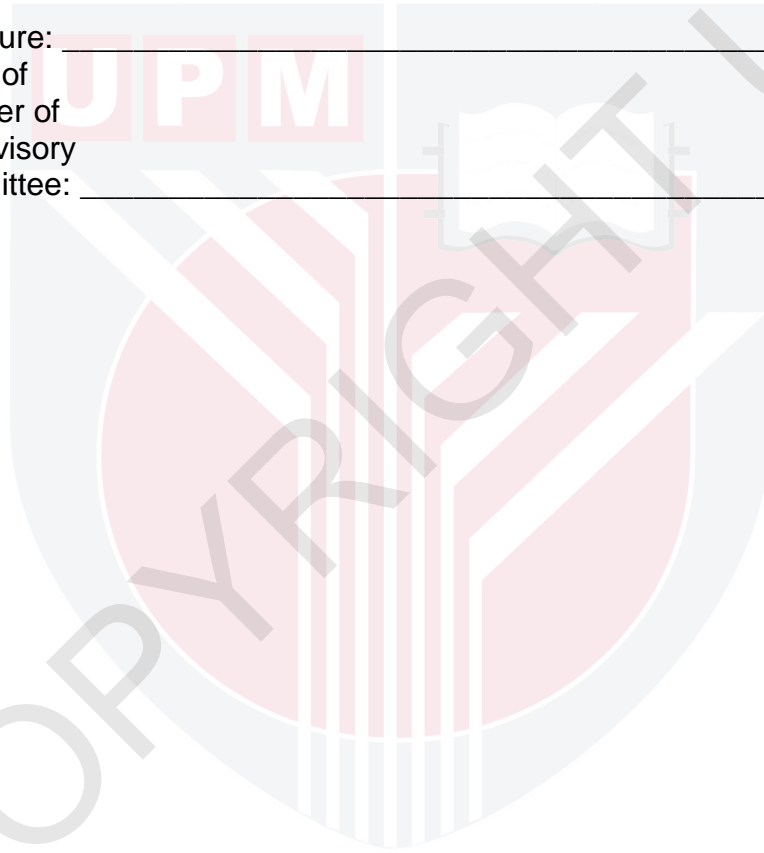
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## LIST OF ABBREVIATIONS

|                  |  |
|------------------|--|
| USDA             | United States Department of Agriculture                    |
| FAO              | Food and Agriculture Organization                          |
| PM <sub>10</sub> | Particulate Matter   |
| PAHs             | Polycyclic aromatic hydrocarbons                           |
| PCDD             | Polychlorinated dibenzo- <i>p</i> -dioxins                 |
| PCDFs            | Polychlorinated dibenzofurans                              |
| IMO              | Indigenous microorganisms                                  |
| EM               | Effective microorganisms                                   |
| BM               | Beneficial microorganisms                                  |
| SWR              | Steamed white rice   |
| AFPW             | Aerated fish pond water                                    |
| KW               | Kitchen waste  |
| MPOB             | Malaysian Palm Oil Board                                   |
| OPT              | Oil palm trunks  |
| OPF              | Oil palm fronds  |
| EFB              | Empty fruit bunches  |
| PPF              | Palm pressed fibres  |
| PKS              | Palm kernel shells   |
| PKC              | Palm kernel cake   |
| POME             | Palm oil mill effluent                                     |
| MTIB             | Malaysian Timber Industry Board                            |
| OM               | Organic matter   |
| PSB              | Photosynthetic bacteria                                    |
| FAMEs            | Fatty acid methyl ester                                    |
| PCR              | Polymerase chain reaction                                  |
| CoA              | Coenzyme A   |
| MIDI             | Microbial identification                                   |
| EPA              | Environmental Protection Agency                            |
| NRAES            | Natural Resource, Agriculture and Engineering Service      |
| TMECC            | Test Methods for the Examination of Composting and Compost |
| CCQC             | California Compost Quality Council                         |
| USEPA            | United States Environmental Protection Agency              |
| CEC              | Council of the European Communities                        |
| cv               | Cultivar   |
| GC               | Gas chromatographic  |
| TSBA             | Tryptic soy broth supplemented with agar                   |
| MIS              | Microbial Identification System                            |
| FTIR             | Fourier Transform Infrared Spectroscopy                    |
| G <sup>-</sup>   | Gram-negative  |
| G <sup>+</sup>   | Gram-positive  |
| PH               | Paddy husk   |
| CS               | Corn stalk   |
| EC               | Electrical conductivity                                    |
| HA               | Humic acid   |
| ATP              | Adenosine triphosphate                                     |
| Vo. rdn          | volume reduction   |
| C/N              | Carbon-to-nitrogen   |

|     |                          |
|-----|--------------------------|
| C/P | Carbon-to-phosphorus     |
| CEC | Cation exchange capacity |
| CFU | Colony form unit         |
| DAS | Day after seedling       |
| TSP | Triple super phosphate   |
| MOP | Muriate of potash        |
| EU  | European Union           |



I certify that a Thesis Examination Committee has met on 6<sup>th</sup> February 2014 to conduct the final examination of Norida Hanim Binti Awing on her thesis entitled "Effects of IMO-Compost on Growth of Maize (*Zea mays* L.)" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

Members of the Thesis Examination Committee were as follows:

**Yiu Pang Hung, PhD**

Associate Professor  
Faculty of Agriculture and Food Sciences  
Universiti Putra Malaysia Bintulu Sarawak Campus  
(Chairman)

**Seca Gandaseca, PhD**

Associate Professor  
Faculty of Agriculture and Food Sciences  
Universiti Putra Malaysia Bintulu Sarawak Campus  
(Internal Examiner)

**Arifin Abdu, PhD**

Associate Professor  
Faculty of Forestry  
Universiti Putra Malaysia  
(Internal Examiner)

**Hasnah Md. Jais, PhD**

Associate Professor  
School of Biological Sciences  
Universiti Sains Malaysia  
Malaysia  
(External Examiner)

---

**NORITAH OMAR, PhD**

Associate Professor and Deputy Dean  
School of Graduate Studies  
Universiti Putra Malaysia

Date: 21 April 2014

## CHAPTER 1

### INTRODUCTION

Fertilizer is very important in enhancing crop yield. However, the use of chemical fertilizers has generally caused environmental problems such as air, water and land degradation. Thus, organic fertilizer is much more preferred due to its minimal negative effect on the environment. It can only supply small amount of nutrients to the plants, but it can be applied continuously. Compost, a type of organic fertilizer is most commonly applied on agricultural land. Most of the composts are generally produced from different sources of wastes. The production of agricultural wastes worldwide has greatly increased and they have to be disposed and managed properly to avoid environmental problems.

According to the United States Department of Agriculture (USDA), production of rice in 2013 was at 473.2 million tons and 2.43 million tons for maize (2013). Rice (*Oryza sativa* L.) is the most important cereal crop for the world's population as staple food (FAO, 2009; Giri and Laxmi, 2000; Singh, 1993) while harvested maize is used for human consumption, livestock, and industrial products. As stated by Gadde *et al.* (2009), farmers generally use the method of field burning to dispose agriculture residues after harvesting and also to destroy harmful insects, weeds and diseases which all have adverse effects on crops in the following year. It is also cheaper to burn these residues than to use herbicides and insecticides. A study by Carl and Fukuya (2010) found that paddy husk (PH) and corn stalks (CS) are also piled or spread in the field, incorporated in the soil, or used as crop mulching.

Cao *et al.* (2008) and Viana *et al.* (2008) found that field burning of one ton paddy residues increased the daily particulate matter, (PM<sub>10</sub>) concentrations by 10 to 15 µg m<sup>-3</sup> releasing 3 kg PM<sub>10</sub>, 60 kg CO, 1460 kg CO<sub>2</sub>, 2 kg SO<sub>2</sub>, CH<sub>4</sub> and NO<sub>x</sub> gases. About 16 types of polycyclic aromatic hydrocarbons (PAHs) including polychlorinated dibenzo-*p*-dioxins, and polychlorinated dibenzofurans (PCDD/Fs) were produced from burning activities (Lu *et al.*, 2009). Air pollutants have significant toxicological properties and are notably potential carcinogens (Carl and Fukuya, 2010; Yang *et al.*, 2006; Korenaga *et al.*, 2001) where they not only effect human health and the environment, but also indirectly the economy of a country (Ryu *et al.*, 2007).

Because of these concerns, there is a need to find an economical alternative way for managing agricultural residues and this can be done through composting. Composting is one of the most attractive alternatives because of its low environmental impact and cost (Bustamente *et al.*, 2008; Canet *et al.*, 2008; Lu *et al.*, 2008), as well as its capacity for generating a valuable product used for improving soil fertility (Weber *et al.*, 2007) or as a growing medium in agriculture and horticulture (Kala *et al.*, 2009; Pérez-Murcia *et al.*,



2005). As widely known, application of compost has many benefits as a slow-release store of N, P, K and micronutrients not found in commercial fertilizer. It also increases the soil's water holding ability because of high organic matter, allows better infiltration of both air and water into the root zone in clay soil. However, most of the compost produced from different sources of wastes is of low quality. There is a need to improve the compost quality by enhancing the biological properties with application of indigenous microorganisms (IMO) from natural sources. Agronomists often used effective microorganisms (EM) and beneficial microorganisms (BM) in agriculture, aquaculture, marineculture and industries. Most of EM and BM are applied mainly in three forms from selected culture, single, multiple and compound strains which are costly compared to IMO from natural sources such as from the forest, pond water and also kitchen wastes (Zhou *et al.*, 2009).

Steamed white rice (SWR) as a carbohydrate source was used in trapping beneficial IMO under bamboo plant litter (Mazzola, 2004; Kyu, 2003). Bamboo through observation attracts IMO as the roots of the bamboo exude sugary substances that attract IMO (Kirk *et al.*, 2004; Szmanski and Patterson, 2003). Bacteria are naturally present in aerated fish pond water (AFPW) and sediments, being regarded as integral to the biological structure, acting upon the metabolism of the aquatic ecosystem and bearing a basic role to water quality. It also contributes to mineralization, utilization as probiotic and employment in fish breeding systems in ponds (Macedo *et al.*, 2011; Sipaúba-Tavares, 2007). Food and organic wastes which consist of left-over food and food preparation wastes from residences, restaurants and cafeteria are known as kitchen waste (KW). It is characterized by a high organic content containing soluble sugars, starch, lipids, proteins, cellulose, and other compounds that are readily biodegradable (Halimatun *et al.*, 2010; Village, 1998), and generally contain few compounds that inhibit bacteria (Wang *et al.*, 2003). Since all these sources have abundant beneficial strain, they were collected, cultured and applied in compost to enhance compost quality and plant growth.

This study was conducted to: (1) identify bacteria strains from steamed white rice (SWR), aerated fish pond water (AFPW) and kitchen wastes (KW) by FAMES; (2) characterize the physico-chemical properties and quality of IMO-compost from paddy husk and corn stalk; and (3) evaluate the effect on nutrient uptake and use efficiency in maize.

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## BIODATA OF STUDENT

Norida Hanim Binti Awing was born on 2<sup>nd</sup> July 1983 at Kampung Maras, Batu Rakit, Kuala Terengganu, Terengganu, Malaysia. She had her primary education at Sekolah Rendah Kebangsaan Mengabang Telipot, Kuala Terengganu, Terengganu, Malaysia. In 1996, Norida's pursued her secondary education at Sekolah Menengah Kompleks Mengabang Telipot, Kuala Terengganu, Terengganu, Malaysia. In 2002, she continued her studies at Universiti Putra Malaysia Bintulu Branch Campus, Sarawak, Malaysia and obtained a Diploma in Agriculture in 2005. In 2009, she was awarded Bachelor of Bioindustry Sciences. She later pursued a Master of Science in Agrotechnology also at Universiti Putra Malaysia.

## LIST OF PUBLICATIONS

### Journal article:

A. Norida Hanim, A. M. Nik Muhamad, O. H. Ahmed, K. Susilawati and A. Khairulmazmi. 2012. Physico-chemical properties of indigenous microorganism-composts and humic acid prepared from selected agro-industrial residues. *African Journal of Biotechnology* 11(34), 8456-8463. Available online at <http://www.academicjournals.org/AJB>. DOI: 10.5897/AJB11.3995. ISSN 1684-5315 © 2012 Academic Journals.

### Conference paper published in proceedings:

A. Norida Hanim, A. M. Nik Muhamad, O. H. Ahmed, K. Susilawati and A. Khairulmazmi. 2012. Selection of indigenous microorganisms in enhancing IMO-compost production. UMT 11<sup>th</sup> International Annual Symposium on Sustainability Science and Management 09<sup>th</sup> – 11<sup>th</sup> July 2012, Terengganu, Malaysia. e-ISBN 978-967-5366-93-2

A. Norida Hanim, A. M. Nik Muhamad, O. H. Ahmed and A. Khairulmazmi. 2014. The application of fatty acids methyl ester ester analysis (FAMEs) for identification of bacteria from three indigenous microorganisms (IMO) sources. International Conference on Beneficial Microbes 2014 27<sup>th</sup> – 29<sup>th</sup> May 2014, Penang, Malaysia.