UNIVERSITI PUTRA MALAYSIA

EFFECTS OF CRUDE HUMIN FROM SELECTED WASTE COMPOSTS ON AMMONIA VOLATILIZATION AND MAIZE (Zea mays L.) CULTIVATION

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By

PALANIVELL A/L PERUMAL

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

September 2012

Especially Dedicated to,

Mr. M. Subramaniam, Mr. Kumar, Ms. Anakilly,

Mr. Anthony Dass Santhanam and family...

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master of Science

EFFECTS OF CRUDE HUMIN FROM SELECTED WASTE COMPOSTS ON AMMONIA VOLATILIZATION AND MAIZE (*Zea mays* L.) CULTIVATION

By

PALANIVELL A/L PERUMAL

September 2012

Chairman : Susilawati Kasim, PhD

Faculty : Faculty of Agriculture and Food Sciences

Waste from oil palm plantations, paddy fields, sawn timber and poultries are substantial. Inappropriate disposal of these wastes can cause environmental problems such as air and land pollution. These problems can be reduced by recycling the wastes through composting. Compost has been used widely to supply nutrients, organic matter into the soil and improves soil physical characteristics. Compost also contains beneficial humic fractions such as humic acids (HA), crude fulvic acids (CFA) and crude humin (CH). Thus, this study was conducted to produce good quality compost and CH as well as to determine the effect of mixing CH with urea and Egyptian rock phosphate (ERP) on ammonia (CH_3) volatilization and selected soil chemical properties. Furthermore, this study was conducted to evaluate the effects of CH and compost on maize growth, nutrient uptake and use efficiency. Composting of rice straw, rice husk, sawdust and palm oil empty fruit bunch (EFB) were carried out in 48 × 35.5 × 34.7 cm sized white polystyrene box. Then, HA, CFA and CH were extracted from compost using standard methods.

Standard procedures were also used to analyze compost, HA, CFA and CH. Rice straw compost had higher ash, nitrogen (N), phosphorus (P), cation exchange capacity (CEC), humic acids (HA), potassium (K) and iron (Fe) contents with lower organic matter (OM), total organic carbon (TOC), C/N and C/P ratio compared to other composts. Sawdust compost HA had higher C, carboxylic, K and Ca content compared to other HA. Crude FA from rice straw compost had highest pH, total K, calcium (Ca), magnesium (Mg) and sodium (Na) contents compared to other CFA. Crude humin from rice straw compost had higher content of ash, N, P and CEC compared to other CH. Humification and mineralization of compost could be the reason for these findings. As reported by researchers, higher humification and mineralization produces high quality compost and HA, which promote higher amount of nutrient content and CEC. Hence, rice straw produced good quality compost, CFA and CH while sawdust compost produced good quality HA. Ammonia (NH_3) loss study was carried out using the closed-dynamic air flow system. Four different CH were mixed with urea and ERP before applied on the surface of the soil. Standard procedures were used to determine NH_3 loss and selected soil chemical properties of incubated soils. Amending urea with CH had no effect on total amount of NH_3 loss. But, addition of the CH significantly increased pH, OM, TOC, CEC and exchangeable cations of Typic Paleudults. Hence, CH from selected waste compost can be used to improve soil chemical properties. A pot study with ten treatments was conducted under rain shelter. Standard procedures were used to determine selected soil chemical properties before and after planting. The plants were measured for stem diameter and height at tasselling stage prior to harvest.

Dry matter production, nutrient uptake and nutrient use efficiency were also measured. Application of sawdust compost (T8) significantly increased maize plant diameter, height, dry matter production, and N, P and K uptake and use efficiency compared to T1 (chemical fertilizer). In treatment T8, sawdust compost supplies 1.2 g HA kg^{-1} soil which increased the nutrient uptake and use efficiency and this observation was consistent with previous study. Hence, sawdust compost (T8) is superior in maize plant growth, nutrient uptake and use efficiency compared to chemical fertilizer and it also reduced usage of N, P and K based chemical fertilizer up to 90%. Application of CH and selected waste composts (rice straw, rice husk and EFB) could be used as an alternative for chemical fertilizers due to their similar effects on maize plants.

Abstrak tesis yang dikemukan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan ijazah Master Sains

KESAN HUMIN MENTAH DARI KOMPOS SISA TERPILIH KE ATAS PEMERUAPAN AMMONIA DAN PENANAMAN JAGUNG (*Zea mays* L.)

Oleh

PALANIVELL A/L PERUMAL

September 2012

Pengerusi : Susilawati Kasim, PhD

Fakulti : Fakulti Sains Pertanian dan Makanan

Bahan buangan dari ladang kelapa sawit, sawah padi, kayu bergergaji dan ternakan ayam adalah banyak. Pelupusan bahan buangan ini secara tidak teratur boleh membawa masalah alam sekitar seperti pencemaran udara dan tanah. Masalah ini dapat dikurangkan dengan mengitar semula bahan buangan tersebut melalui pengkomposan. Kompos telah digunakan secara meluas untuk membekalkan nutrien, bahan organik ke dalam tanah dan untuk menambah baik sifat fizikal tanah. Kompos juga mengandungi bahan bermanfaat pecahan humik seperti asid humik (HA), asid fulvik mentah (CFA), dan humin mentah (CH). Oleh itu, kajian ini telah dijalankan untuk menghasilkan kompos dan CH berkualiti tinggi, menentukan kesan campuran CH dengan urea dan batuan fosfat Mesir ke atas pemeruapan amonia dan sifat kimia tanah terpilih. Objektif lain kajian ini adalah untuk mengukur kesan CH dan kompos terhadap pertumbuhan, pengambilan nutrien dan kecekapan penggunaan nutrien oleh jagung. Pengkomposan

jerami padi, sekam padi, habuk kayu dan tandan kosong kelapa sawit telah dijalankan dalam kotak polisterin putih bersaiz 48 x 35.5 x 34.7 cm. Selepas itu, HA, CFA, dan CH telah diekstrak dari kompos tersebut dengan menggunakan kaedah piawai. Kaedah piawai telah digunakan untuk menganalisa kompos, HA, CFA dan CH. Kompos jerami padi mempunyai kandungan abu, N, P, keupayaan pertukaran kation (KPK), HA, K dan Fe yang tinggi dengan kandungan bahan organik, jumlah karbon organik, nisbah C/N dan C/P yang rendah berbanding dengan kompos yang lain. Asid humik dari kompos habuk kayu mempunyai kandungan C, karboksilik, K dan Ca yang lebih tinggi berbanding dengan HA kompos yang lain. Asid fulvik mentah daripada kompos jerami padi mempunyai pH, jumlah K, Ca, Mg, dan Na yang tertinggi berbanding dengan CFA yang lain. Humin mentah daripada kompos jerami padi mengandungi abu, N, P, dan KPK yang lebih tinggi berbanding dengan humin mentah yang lain. Humifikasi dan pemineralan semasa pengkomposan merupakan penyebab dalam penemuan kajian ini. Seperti yang dilaporkan oleh para penyelidik, humifikasi dan pemineralan yang tinggi adalah penting dalam penghasilan kompos dan HA yang berkualiti lebih tinggi, serta menggalakan kandungan nutrien dan KPK yang lebih tinggi. Maka, jerami padi telah menghasilkan compost, CFA dan CH yang berkualiti manakala, habuk kayu telah menghasilkan HA yang berkualiti. Kajian pemeruapan amonia telah dijalankan dengan menggunakan sistem aliran udara dinamik-tertutup. Empat jenis CH telah dicampurkan dengan urea, batuan fosfat Mesir sebelum diaplikasi di permukaan tanah. Kaedah piawai telah digunakan bagi menentukan kehilangan amonia dan sifat kimia tanah terpilih bagi tanah yang

telah diinkubasikan. Pembaikan urea dengan CH tidak menunjukkan sebarang kesan ke atas jumlah kehilangan amonia. Tetapi, penambahan CH memberi kesan yang ketara terhadap kenaikan pH, bahan organik, jumlah karbon organik, KPK dan kation tukarganti bagi tanah *Typic Paleudults*. Maka, CH dari kompos bahan buangan terpilih boleh digunakan untuk menambah baik sifat kimia tanah. Satu kajian penanaman dalam pasu dengan sepuluh rawatan telah dijalankan di bawah pelindung hujan. Kaedah piawai telah digunakan untuk menentukan sifat kimia tanah terpilih sebelum dan selepas penanaman. Ukur lilit batang dan ketinggian pokok jagung telah ditentukan sebelum dituai, iaitu pada fasa baru keluar rumbainya. Penghasilan berat kering, pengambilan nutrien dan kecekapan penggunaan nutrien turut ditentukan. Penggunaan kompos habuk kayu (T8) menunjukkan peningkatan ketara terhadap ukur lilit, ketinggian, penghasilan berat kering, pengambilan N, P dan K serta kecekapan penggunaannya berbanding dengan T1 (baja kimia). Kompos habuk kayu membekalkan 1.2 g HA kg^{-1} tanah yang mana telah meningkatkan pengambilan dan kecekapan penggunaan nutrien dan pemerhatian ini adalah konsisten dengan kajian sebelumnya. Maka, kompos habuk kayu (T8) telah memberikan pertumbuhan, pengambilan dan kecekapan penggunaan nutrien yang lebih baik pada pokok jagung berbanding dengan baja kimia dan ia juga mengurangkan penggunaan baja kimia N, P dan K sehingga 90%. Penggunaan CH dan kompos bahan buangan terpilih (jerami padi. sekam padi dan tandan kosong kelapa sawit) dapat dijadikan alternatif kepada baja kimia kerana ia memberikan kesan yang sama terhadap tanaman jagung.

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I certify that a Thesis Examination Committee has met on 14 September 2012 to conduct the final examination of Palanivell A/L Perumal on his thesis entitled "Effects of Crude Humin from Selected Waste Composts on Ammonia Volatilization and Maize (*Zea mays* L.) Cultivation" 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.

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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 Master of Science. The members of the Supervisory Committee were as follows:

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Date:

DECLARATION

I declare that this thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

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PALANIVELL A/L PERUMAL

Date: 14 September 2012

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LIST OF ABBREVIATIONS

RS	Rice straw
RH	Rice husk
SD	Sawdust
EFB	Empty fruit bunch
HF	Humic fractions
HA	Humic acid
FA	Fulvic acid
CFA	Crude fulvic acid
CH	Crude humin
K-humin	Potassium-humin
ERP	Egyptian rock phosphate
TSP	Triple superphosphate
MAP	Monoammonium phosphate
MOP	Muriate of potash
KOH	Potassium hydroxide
NaOH	Sodium hydroxide
HCl	Acid hydrochloric
KBr	Potassium bromide
FTIR	Fourier transform infrared
C/N	Carbon/Nitrogen
C/P	Carbon/Phosphorus
S.E.	Standard error
MW	Molecular weight
CEC	Cation exchange capacity
w/v	Weight/volume
w/w	Weight/weight
rpm	Revolutions per minute
var.	variety
DAS	Days after sowing seeds

CHAPTER 1

INTRODUCTION

Malaysia produces agricultural crops such as oil palm, rubber, paddy as well as timber products. In Malaysia, about 1.9 million metre cubes (m^3) sawntimber was exported in the year 2009 (MITB, 2010). From January to Jun 2009, about 2,460,000 metric tonnes paddy was produced in Malaysia (MOA, 2009). According to the Malaysian Palm Oil Board, about 90.048 million tonnes of fresh fruit bunches of oil palm were produced in 2009 (Wahid, 2010). Federation of Livestock Farmers' Associations of Malaysia records about 516.23 million birds (broiler) were produced while 43.08 million live birds were exported in 2009 (FLFAM, 2011a, b).

Production of these commodities produce enormous quantity of waste such as oil palm empty fruit bunch, rice straw, rice husk and sawdust. The most common waste produced in the oil palm industry is the empty fruit bunch (EFB) which records about 25% of the total palm fruit bunch (Keu, 2005). Most of these wastes are not properly disposed. Rice straw is usually burned (Chen *et al*., 2008) *in situ* after harvest. Rice husk and sawdust are burned under controlled condition in the mill or dumped. However, EFB is mostly applied in the oil palm plantations as mulch (Zakaria *et al.* 2000) and it takes longer time to degrade.

Burning of agricultural or organic wastes release hazardous particles (Chen *et al*., 2008), hazardous gases and green house gases into the atmosphere

and this causes a lot of environmental and health problems (U.S.EPA, 2001). Environmental problems due to inappropriate management of agricultural wastes can be reduced by composting them (Thompson, 2009). Composting can be defined as rapid reduction of large volumes of organic materials through biological process (Geisel and Unruh, 2007).

Composting of these agricultural wastes produce composts which are rich in humic fractions (Stevenson, 1994; Tan, 2003). Humic fractions are heterogeneous organic macromolecules, which play important roles in many process of environmental and agricultural interest (Fabbri *et al.*, 1996). Humic fractions are the major components of organic matter in soil and they are beneficial to plants (Schmidt *et al*., 2007).

Soluble humic substances such as humic acids and fulvic acids have been studied extensively due to their higher solubility and usefulness. Within these three humic materials, humin is least studied and chemically analysed because of its insolubility and macromolecular structure (Rice and MacCarthy, 1988). Previous studies on humin were mainly focused on the contaminations (Helal *et al.,* 1998; Helal *et al.,* 2006).

Only few studies have been conducted on humin as plant nutrients. Since humin has almost identical functional groups and elemental composition as humic acids, it may be used as soil amendment and fertilizer plants (Helal *et al*., 1998; Rice and MacCarthy, 1991). A previous study has shown that humin from composted sago waste increased dry matter production and

nutrient use efficiency in maize plant (Petrus *et al*., 2010). Moreover, extraction of humin using potassium hydroxide increased potassium content in humin and this K-humin has potentials to be used as potassium fertilizer for plants uptake. Addition of crude humin from selected waste composts can be used as replacement for chemical based K fertilizers. Moreover, presence of humic fractions in compost may increase the maize plants height, diameter, nutrient uptake and nutrient use efficiency.

On the other hand, the effect of amending urea with humin on ammonia loss, nitrogen, phosphorus and potassium use efficiency are still unknown. Application of urea by surface broadcasting, a normal practice in agriculture causes nitrogen loss through urea hydrolysis and ammonia volatilization (Francis *et al.*, 2008). Higher CEC of humin may effectively retain ammonium ions from volatilizing from urea. Hence, soil quality may be improved with higher organic matter, mineral content and CEC of humin

The objectives of this study were to:

(i) produce and characterize compost and humic substances from the composted wastes

(ii) determine the effect of crude humin on ammonia loss and selected soil chemical properties,

(iii) determine the effect of compost and crude humin from composted selected wastes on *Zea mays* L. growth, nutrient uptake and nutrient use efficiency.

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