UNIVERSITI PUTRA MALAYSIA

EFFECTS OF PEAT DERIVED HUMIC ACID ON AMMONIA VOLATILIZATION FROM UREA FERTILIZER

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By

LEE JIA HUEY

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

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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 PEAT DERIVED HUMIC ACID ON AMMONIA VOLATILIZATION FROM UREA FERTILIZER

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LEE JIA HUEY

March 2011

Chairman : Associate Professor Osumanu Haruna Ahmed, PhD

Faculty : Faculty of Agriculture and Food Sciences (Bintulu)

There are about 2.7 million hectares of peat swamps in Malaysia, which account for 8% of the country's total area. 1.7 million hectares are in Sarawak (63%). Peats are well-known for their high organic matter. For instance, humic matter can be further categorized into humin, fulvic and humic acids. Being organic in nature, humic acid is an ideal material to be mixed with ammonium and potassium to produce organically amended fertilizer. However, there are several factors that limit the production of the fertilizer mentioned above. For instance, extraction of humic acids is a time consuming process. Furthermore, type and concentration of extractant also influence the yield of humic acids. These information are critical in the study of humic acids but they are lacking for humic acids isolated from Sarawak peat. Hence, first part of this study was to investigate the effect of different levels of extractant concentration on the yield of humic acid extracted from Sarawak peat soil (saprists). Modified standard procedure was adopted by using six different concentrations of NaOH and KOH to extract humic acid. Results showed that there was a linear relationship between levels of concentrations and yield of humic acid and the concentration that gave optimum yield was 0.5 M. In terms of economics, this finding might be useful especially in large scale isolation of humic acids from tropical peats. As humic acids contain quinone that could function as urease inhibitor, humic acids are useful in reducing ammonia loss from urea. However, limited information is known regarding effect of humic acids isolated from Sarawak peat on ammonia volatilization. Hence, the objective of second part of the study was to evaluate the effect of peat derived humic acid on ammonia volatilization from urea. Effectiveness of the organically amended urea was evaluated under laboratory condition. Ten treatments namely, urea (liquid), 0.5 M KOH, urea + 0.5 M KOH, urea + humic acid without purification (0.75, 1.00 and 4.00 g), urea + humic acid purified once (0.75, 1.00 and 4.00 g) and control (soil alone) were used in this study with the aim of reducing nitrogen loss from urea. A closed dynamic air flow system was used to estimate nitrogen loss from soil. A 250 g of mineral soil at field capacity (60% moisture content) was used. The amounts of ammonia loss from the applied treatments were evaluated daily where the ammonia collected in boric acid was titrated with 0.01 M HCl every 24 hours until the loss decreased to less than 0.1%. Similar experiment was also set up in order to determine the actual time of ammonium and nitrate retention in soil. At the end of the fertilizer evaluation, soil samples were analyzed for pH (water and KCl), ammonium and nitrate contents. Results showed that the use of 4.00 g of humic acids significantly reduced ammonia volatilization. Treatments with humic acid also showed significantly higher amount of exchangeable ammonium and available nitrate compared to treatments without humic acid. However, there was no significant difference between humic acid without purification and humic acid purified once. This suggests that purification could be ignored if large scale extraction of humic acids is to be done. Apart from reducing the time needed to obtain humic acid, the outcome of this study will also help to reduce their production cost.

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

KESAN ASID HUMIK YANG DIEKSTRAK DARIPADA TANAH GAMBUT KE ATAS PENGEWAPAN AMONIA DARI BAJA UREA

Oleh

LEE JIA HUEY

Mac 2011

Pengerusi : Profesor Madya Osumanu Haruna Ahmed, PhD

Fakulti : Fakulti Sains Pertanian dan Makanan (Bintulu)

Terdapat sekira-kiranya 2.7 juta hektar kawasan tanah gambut di Malaysia, di mana ini merangkumi 8% daripada jumlah kawasan negara. Di antara itu, sebanyak 1.7 juta hektar adalah terdapat di Sarawak (63%). Tanah gambut terkenal dengan kandungan bahan organiknya yang tinggi. Sebagai contoh, bahan humik yang boleh dikategorikan kepada humin, asid fulvik dan asid humik. Asid humik merupakan sesuatu bahan yang sesuai untuk dicampur dengan amonium untuk menghasilkan baja yang berunsur organik. Walaubagaimanapun, terdapat beberapa faktor yang menghadkan penghasilan baja tersebut. Sebagai contoh, pengekstrakan asid humik memakan masa yang panjang. Tambahan pula, jenis dan kepekatan larutan ekstrak juga mempengaruhi kuantiti asid humik yang diekstrak. Maklumat sebegini adalah penting dalam kajian asid humik tetapi ia adalah kekurangan

untuk asid humik yang diekstrak dari tanah gambut Sarawak. Justeru itu, bahagian pertama daripada kajian ini ialah untuk mengkaji kesan beberapa tahap kepekatan yang berlainan ke atas asid humik yang diekstrak dari tanah gambut Sarawak jenis Sapris. Terdapat enam tahap kepekatan dari dua jenis larutan ekstrak telah dikaji. Keputusan menunjukkan bahawa terdapat hubungan linear antara kepekatan larutan ekstrak dan jumlah asid humik yang diekstrak. Kepekatan yang memberi keputusan optimum ialah 0.5 M. Dari segi ekonomi, keputusan yang didapati mungkin berguna dalam penghasilan asid humik dari tanah gambut tropika. Asid humik mengandungi quinon yang dapat berfungsi sebagai “urease inhibitor”. Dengan ini, asid humik adalah berguna dalam mengurangkan kehilangan amonia dari urea. Walaubagaimanapun, maklumat yang berkaitan dengan kesan asid humik yang diekstrak dari tanah gambut Sarawak ke atas pengewapan amonia adalah terhad. Oleh itu, objektif bahagian kedua kajian ini ialah mengkaji kesan asid humik yang berasal dari tanah gambut Sarawak ke atas pengewapan amonia dari urea. Baja urea dicampur dengan asid humik yang telah diekstrak. Kesan campuran baja tersebut dinilai di dalam makmal. Sebanyak sepuluh rawatan iaitu urea (larutan), 0.5 M KOH, urea+ 0.5 M KOH, urea+ asid humik tanpa purifikasi (0.75, 1.00 dan 4.00 g), urea+ asid humik yang dipurifikasi (0.75, 1.00 dan 4.00 g) serta kawalan (tanah sahaja) digunakan di dalam eksperimen ini dengan tujuan untuk mengurangkan kehilangan nitrogen dari urea. Satu sistem pengaliran udara dinamik yang tertutup diguna untuk mengkaji kehilangan Nitrogen dari tanah. Tanah mineral sebanyak 250 g yang mengandungi 60% kelembapan telah

digunakan dalam eksperimen tersebut. Jumlah amonia yang hilang dari rawatan tersebut dinilai setiap hari di mana amonia yang dikumpul dalam asid borik dititrat dengan 0.01N HCl sehingga kehilangan amonia turun kepada 0.1%. Eksperimen yang mirip juga dijalankan untuk menentukan kandungan amonium dan nitrat di dalam tanah. Pada akhir eksperimen, pH (air dan KCl), kandungan amonium dan nitrat tanah mineral tersebut dianalisa. Keputusan menunjukkan bahawa penggunaan asid humik 4.00 g dapat mengurangkan pengewapan amonia, tetapi tidak ada perbezaan antara asid humik yang dipurifikasi dan tanpa purifikasi. Keputusan ini telah mencadangkan bahawa langkah purifikasi mungkin boleh dibatalkan jika pengekstrakan asid humik secara besar-besaran dijalankan. Selain daripada menjimatkan masa, keputusan kajian ini juga dapat mengurangkan kos yang terlibat dalam penghasilan baja jenis tersebut.

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I certify that a Thesis Examination Committee has met in 2011 to conduct the final examination of Lee Jia Huey on her thesis entitled “Effects of Peat Derived Humic Acid on Ammonia Volatilization from Urea Fertilizer” 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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DECLARATION

I declare that the thesis is my original work except for the 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.

LEE JIA HUEY

Date: 22 March2011

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CHAPTER 1

INTRODUCTION

There are about 2.7 million hectares of peat swamps in Malaysia, accounting for 8% of the country's total land area, of which 1.7 million hectares (63%) are in the deltas and coastal plain of Sarawak (Department of Irrigation and Drainage Sarawak, 2008). Peat soil is well-known for its substantial part as organic matter (>80%) (Gondar *et al.,* 2005). Between 60 to 80% of the soil organic matter comprises humic matter (Brady and Weil, 2002).

Generally, humic matter, or humic material, refers to the humified organic material fraction of humus (Tan, 2003). Based on solubility, humic matter can be further divided into three groups, namely fulvic acids (FA), humic acids (HA) and humin (Brady and Weil, 2002). A collective term for these groups is humic substances. Humic substances are mixture of amorphous, polydispersed substances with yellow, brown to black colour. Other common characteristics include hydrophilic, acidic and high in molecular weight (Stevenson, 1994), that range from several hundreds to thousands of atomic units or Daltons (Tan, 2003).

Isolation of humic substances such as HA is laborious and time consuming. Factors that affect the quality and quantity of HA yield isolated from soils include extraction, fractionation and purification periods, types of extractants

(Zaccone *et al*., 2007) and others. The extraction, fractionation and purification periods of HA vary from 12 hours to 7 days (Tan, 2003; Stevenson, 1994). Pretreatment is needed in some cases depending on the type of soil. Extraction is the first step in isolating humic substances, with the aim of extracting humic substances (FA and HA) from the soil (Tan, 2003). The usual practice is 24 hours of extraction time (Inbar *et al*., 1990). Common extractants include neutral pyrophosphate, mixture of pyrophosphate, sodium hydroxide and potassium hydroxide (Hayes, 2006). However, some reagents are said to induce auto-oxidation of humic substances and this leads to alterations of the chemical composition of HA (Tan, 2003). Besides the nature of reagents, concentration of the reagents play important role too. For instance, it is generally believed that stronger NaOH solution extracts more HA but it alters the chemical characteristics of HA.

Extraction is followed by fractionation, which is a process to separate HA from FA. A large number of chemical and physical methods are available for fractionation of humic substances (Tan, 2003). Fractionation time ranges between 12 hours and 24 hours (Stevenson, 1994) but most studies use 24 hours (Ahmed *et al*., 2004; Stevenson, 1994; Inbar *et al*., 1990). The last step in the isolation of humic substances is purification. The HA is purified by reducing the content of undesired material in it. Purification periods usually range from 2 to 7 days. However, the work of Ahmed *et al.* (2004) showed that purification time for HA from composted pineapple leaves could be reduced to one day. However, Ahmed *et al.* (2005) managed to reduce extraction time of humic acid in compost from 48 hours to 3 hours.

The above mentioned information is important in the study of HA but it is lacking for peat soil HA (Zaccone *et al*., 2007). Apart from the isolation procedures, another problem which remains unclear is the relationship between peat soil HA yield and the extractant used. This relationship is important because it allows the estimation of maximum or optimum HA yield especially if commercial scale production of HA-related product is to be carried out.

Though isolation of HA is not an easy job, scientists are still interested to study HA. In agriculture, humic matter has drawn the attention as the growth and yields of crops have always been better when plants are grown in soils rich in humic matter. Ashraf *et al.* (2005) also reported significant increase in the yield of mung beans treated with 0.005% HA. The work of Atiyeh *et al.* (2002) showed that the incorporation of HA into soilless plant growth media increased the growth of both tomato and cucumber plants significantly. Also, the addition of HA to corns planted in pots containing Al increased dry matter production by 32.5 to 42.5% over those with no unit of HA and the plants appeared healthy and green (Tan and Binger, 1986).

Apart from this direct effect on plant growth, humic matter is also said to contribute indirectly. For instance, the presence of quinones (urease inhibitor) in humic matter has made it a possible solution to ammonia volatilization, which is one of the major pathways of nitrogen loss in field (Siva *et al*., 1999). Brady and Weil (2002) also claimed that treating urea with materials that slow its dissolution or inhibits its hydrolysis to ammonium could help to reduce ammonia losses. As urea hydrolysis could be slowed down in acidic condition, HA with its acidic nature and high cation exchange capacity (CEC) could be helpful in reducing ammonia volatilization. The work of Ahmed *et al.* (2006) also showed that inclusion of HA and zeolite successfully minimized the conversion of ammonium to nitrate.

With the development of organically amended nitrogen fertilizer from tropical peat and urea, ammonia volatilization might be reduced in the presence of HA. This will not only help to improve uptake efficiency of nitrogenous fertilizers, but also eventually contribute to the reduction of environmental pollution from agricultural field. However, the effectiveness of peat soil HA on reducing ammonia volatilization from urea is not well studied. Little is known about the interaction between peat soil HA and urea.

Therefore, this study was conducted to investigate the relationship between concentrations of extractants and yields of HA. The influence of extractants and their concentrations on selected chemical characteristics of HA was also evaluated. The second objective was to investigate the effectiveness of amending peat soil HA with urea in reducing ammonia volatilization from urea.

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LIST OF PUBLICATION

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