UNIVERSITI PUTRA MALAYSIA

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By

AINI AZURA BINTI ALI

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

October 2010

DEDICATION

This thesis is dedicated to:

My beloved parents

Ali Bin Mahada

And

Khadijah Binti mahmood

Sisters and brothers in law

Zawatil Amal and Azman Nor

Izan Khairayni and Khairul Hisam

My lovely nephews and niece

Shahindah Nisa Binti Azman

Adam Ashraf Bin Khairul Hisam

Umar Muhaimin Bin Azman

Umar Mujahid Bin Azman

Khaleesya Adlina Binti Khairul Hisam

Umar Muzammier Bin Azman

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the Requirement for the degree of Master of Science

CADMIUM AND ZINC LEVELS IN THE SOILS AND OIL PALM TISSUES FROM LONG-TERM APPLICATION OF PHOSPHATE ROCK FERTILIZERS

By

AINI AZURA BINTI ALI

October 2010

Chairman : Che Fauziah Ishak, PhD

Faculty : Agriculture

There are reports from temperate region regarding Cd accumulation in soils due to the application of phosphate rocks (PR) in agriculture soil. Oil palm plantations in Malaysia used phosphate rocks as the main source of P fertilizer since 1960s till the present time. There are speculations that this continuous and long-term application of phosphate rock may led to the accumulation of Cd in soil and then, increasing the availability of this element for plant uptake and thus, could enter human body via food chain. Zinc also is of increasing concern as this element can be found in PR as an impurity, and under natural condition, Zn to Cd ratio in PR is high.

Therefore, this study was conducted to determine the Cd and Zn concentrations in soil and plant parts of three different ages (<10, >15, >20 years). To carry out this investigation, six soil series were collected from two well managed oil palm plantations (one in coastal and another in inland areas) which are of second generation of planting.

Jawa, Selangor and Sedu Series were selected from coastal areas, while Munchong, Rengam and Segamat Series were collected to represent inland areas. Fronds and fruitlets were also collected along with the soils (paired sampling). Correlation study was done to determine the relationship between Cd and Zn in soils and soil properties and also with Cd and Zn in the plant tissue.

There was no accumulation of Cd in all soil series but Zn accumulation was observed for Selangor and Segamat Series. Cadmium and Zn were highest in Segamat Series compared with the other soil series. Fruitlets show no increase in Cd and Zn concentrations but Jawa and Selangor Series show increasing values of Zn concentration in the fronds. Cadmium exceeded the Investigation Level for Malaysian soils of 0.3 mg kg^{-1} but Zn was below the investigation level of 95 mg kg^{-1}. Cadmium and Zn concentration in fruitlets were below the Maximum Permitted Concentration (MPC) of 1 and 40 mg kg^{-1} for Cd and Zn, respectively, as stated in the Malaysian Food Act (1983) and Food Regulations (1985). Correlation study reveals that soil pH and clay content were the soil properties that control Cd and Zn concentration in soil. Cadmium in soil and soil solution most probably have contributed to the Cd concentration in fruitlet (edible part) whereas Cd and Zn in soil may influence the uptake of these elements by the oil palm tree.

To verify the findings of the field study, Cd and Zn adsorption studies were carried out. Also, studies on pH effect on adsorption and competitive adsorption between Zn and Cd were conducted. This study involved all the six soil series except for adsorption envelope which was only done for the Segamat and Selangor Series. The highest Cd and

Zn accumulation in Segamat Series had been proven by the adsorption isotherm. Cadmium adsorption was depressed by the presence of Zn, leading to the no accumulation of Cd in all the soils series. Increasing soil pH in Selangor Series, with increase of oil palm age, led to the accumulation of Zn in this soil series.

The third study (glasshouse) was conducted to determine Cd content in oil palm seedlings planted in soil, fertilized with PR and amended with POME cake and lime, which are two common soil amendment used in the plantation. Also, the study was done to determine whether these amendments affect Zn and P uptake by the oil palm seedlings.

Lime added in Jawa Series tends to decrease Cd content in the root as shown by the decreasing exchangeable fraction concentration with the increasing rates. Meanwhile, POME amendment caused exchangeable and water soluble Cd fractions concentration to increase with the increasing rates. However, there was no influence on the Cd content in plant parts. Meanwhile, Zn content increased in root and leaf as exchangeable Zn fraction also increased between the rates, and for P, the content increased in all plant parts. POME and lime added to Segamat Series tend to decrease water soluble and organic P fractions throughout the rates.

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

LEVEL CADMIUM DAN ZINK PADA TANAH DAN TISU KELAPA SAWIT DARIPADA PENGGUNAAN JANGKA PANJANG BAJA BATUAN FOSFAT

Oleh

AINI AZURA BINTI ALI

Oktober 2010

Pengerusi : Che Fauziah Ishak, PhD

Fakulti : Pertanian

Terdapat laporan dari kawasan beriklim sederhana yang menunjukkan pengumpulan Cd di dalam tanah berikutan penggunaan batuan fosfat (BF) pada tanah pertanian. Ladang kelapa sawit di Malaysia menggunakan BF sebagai sumber utama baja P sejak tahun 1960an sehingga kini. Terdapat spekulasi bahawa penggunaan BF secara berterusan dalam jangka masa panjang menjadikan Cd berkumpul di dalam tanah yang boleh menambahkan ketersediaan elemen ini untuk diambil oleh tumbuhan dan seterusnya memasuki tubuh manusia menerusi rantai makanan. Kebimbangan terhadap Zn juga semakin meningkat berikutan kehadiran elemen ini di dalam BF sebagai bendasing dan pada keadaan semulajadi, nisbah Zn kepada Cd adalah tinggi.

Oleh itu, kajian ini dijalankan untuk menentukan kepekatan Cd dan Zn pada tanah dan bahagian pokok kelapa sawit yang mempunyai tiga umur pokok yang berbeza (<10, >15,

>20 tahun). Bagi mengkaji isu ini, enam siri tanah diambil dari dua ladang yang diuruskan secara berjadual (kawasan pinggir laut dan pedalaman) dan telah melalui proses tanam semula untuk kali kedua. Siri Jawa, Selangor dan Sedu dipilih dari kawasan pinggir laut manakala Siri Munchong, Rengam dan Segamat diambil untuk mewakili kawasan pedalaman. Daun dan buah kelapa sawit turut diambil bersama-sama tanah tersebut (persampelan berpasangan). Kajian korelasi dijalankan untuk menentukan hubungan antara Cd dan Zn pada tanah dengan ciri tanah, dan juga dengan kepekatan Cd dan Zn pada tisu tumbuhan.

Tiada pengumpulan Cd pada semua siri tanah tetapi terdapat pengumpulan Zn pada Siri Selangor dan Segamat. Cadmium dan Zn tinggi pada Siri Segamat berbanding siri tanah yang lain. Buah kepala sawit tidak menunjukkan peningkatan kepekatan Cd dan Zn tetapi Siri Jawa dan Selangor menunjukkan peningkatan kepekatan Zn pada daun. Cadmium melebihi aras kajian untuk tanah Malaysia (0.3 mg kg^{-1}) tetapi Zn berada di bawah aras kajian tersebut (95 mg kg^{-1}). Kepekatan Cd dan Zn pada buah kelapa sawit berada di bawah tahap yang dibenarkan (MPC) (masing-masing 1 and 40 mg kg^{-1}) seperti yang dinyatakan dalam Akta Makanan Malaysia (1983) dan Peraturan Makanan (1985) (berdasarkan berat basah). Kajian korelasi menunjukkan pH tanah dan kandungan lempung merupakan ciri tanah yang mengawal kepekatan Cd dan Zn pada tanah. Besar kemungkinan Cd pada tanah dan air tanah menyumbang kepada kepekatan Cd pada buah kelapa sawit (bahagian yang dimakan) sementara itu Cd dan Zn pada tanah mungkin mempengaruhi pengambilan elemen ini oleh pokok kelapa sawit.

Bagi menjelaskan keputusan kajian di ladang ini, kajian penjerapan Cd dan Zn telah dilakukan. Juga, kajian kesan pH terhadap penjerapan dan penjerapan kompetitif antara

Cd dan Zn telah dijalankan. Kajian ini melibatkan kesemua enam siri tanah melainkan untuk kajian kesan pH terhadap penjerapan, yang hanya melibatkan Siri Segamat dan Selangor. Pengumpulan dan kandungan Zn yang tinggi pada Siri Segamat telah dibuktikan oleh penjerapan isoterma. Penjerapan Cd telah berkurangan dengan kehadiran Zn yang menjadikan Cd tidak berkumpul pada semua siri tanah. pH tanah meningkat bersama dengan peningkatan umur pokok kelapa sawit membawa kepada pengumpulan Zn pada Siri Selangor.

Kajian ketiga (rumah kaca) telah dijalankan untuk menentukan kandungan Cd pada anak benih kelapa sawit yang ditanam pada tanah yang dibaja dengan BF, ditambah dengan POME dan kapur yang merupakan bahan pembaikan tanah yang biasa digunakan di ladang. Kajian ini juga dijalankan, untuk menentukan sama ada bahan tambahan ini mempengaruhi pengambilan Zn dan P oleh kelapa sawit.

Kapur yang ditambah pada tanah Siri Jawa menjadikan kandungan Cd pada akar berkurangan sebagaimana yang ditunjukkan oleh kepekatan bentuk bertukarganti yang berkurangan dengan bertambahnya kadar kapur. Sementara itu, penambahan POME menyebabkan kepekatan Cd dalam bentuk bertukarganti dan larut air meningkat dengan meningkatnya kadar POME. Walaubagaimanapun, kandungan Cd pada bahagian tumbuhan tidak dipengaruhi. Sementara itu, kandungan Zn pada akar dan daun meningkat sebagaimana yang ditunjukkan oleh Zn dalam bentuk bertukarganti yang meningkat mengikut kenaikan kadar, dan untuk P, kandungannya meningkat untuk semua bahagian tumbuhan. POME dan kapur yang ditambah pada Siri Segamat

menjadikan P dalam betuk larut air dan organik berkurangan secara keseluruhan megikut kadar.

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I certify that a Thesis Examination Committee has met on **18 October 2010** to conduct the final examination of Aini Azura Binti Ali on her thesis entitle "**Cadmium and Zinc Levels in the Soils and Oil Palm Tissues from Long-Term Application of Phosphate Rock Fertilizers"** 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 Examination Committee were as follows:

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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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DECLARATION

I declare that the 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 institutions.

AINI AZURA BINTI ALI

Date:

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