UNIVERSITI PUTRA MALAYSIA

AMELIORATION OF SOIL ACIDITY BY LIMING FOR RICE GROWN ON ACID SULPHATE SOIL IN PENINSULAR MALAYSIA

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By

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

AMELIORATION OF SOIL ACIDITY BY LIMING FOR RICE GROWN ON ACID SULPHATE SOIL IN PENINSULAR MALAYSIA

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ELISA AZURA AZMAN

APRIL 2012

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Faculty : Agriculture

A study was conducted in Merbok, Kedah, Malaysia. The study area was a paddy field on acid sulfate soil classified as Merbok Series (*Typic Sulfaquents*). This soil is highly acidic containing high Al concentration. Around 3000 ha of land in Merbok, Kedah are cultivated with rice, variety MR 219. Currently, paddy yield is less than 2 t ha^{-1} $season^{-1}$, this is below the national average of 4 t ha^{-1} $season^{-1}$. Therefore, the objective of this study was to suggest ways of ameliorating an acid sulfate soil in Merbok, Kedah, Malaysia. A series of laboratory experiments, glasshouse studies and field trials were conducted.

The first study is laboratory experiment. The objective was to determine the effects of high Al concentration and low pH on rice seeds germination, root morphology and organic acids release. Rice seeds (MR 219) were separately exposed into two conditons which are in solutions containing various concentration of Al (10, 20, 30,

40 and 50 µM) and various water pH (3, 4, 5, 6 and 7) which the pH was adjusted using 0.01 M HCl or NaOH. Results of the study showed that root length decreased with increasing Al concentrations, while the opposite was true for the pH. The trend for the change of root surface area with Al concentration and pH is the same as that of the root length. The critical Al concentration for rice growth is 15 µM and the optimal pH for rice root to grow is 6. At low pH and high Al concentration, the rice roots secreted citrate and/or oxalate which subsequently formed Al-citrate and Al-oxalate, respectively. This, to a certain extent, had reduced Al toxicity. This is the mechanism of rice slight tolerance to Al toxicity.

The second study is glasshouse study. The objective was to determine the effects of lime application on the soil chemical properties and the growth of rice under glasshouse conditions. GML and hydrated lime were applied 2 weeks, while liquid lime was applied a day prior to rice seeding; MR 219 rice variety was used in this experiment. It was found that the application of 4 t ha^{-1} of GML had produced the highest rice yield of 8.2 t ha^{-1}. Relative rice yield is negatively correlated with the soil pH. At harvest, the soil pH exceeded 6 for all the treated soils and this showed that as soil pH increased, exchangeable Ca increased. Soil treated with 2 t ha^{-1} of hydrated lime gave the highest exchangeable Ca in the soil of 11.86 $cmol_c$ kg^{-1} soil. At this rate of application, the concentration of Ca in the root was 0.12%.

The third study was field trial conducted in Merbok. The objective was to increase rice production on an acid sulfate soil under rain-fed condition in Merbok, Kedah, Malaysia, using various lime sources. The soil was treated with ground magnesium limestone, hydrated lime and liquid lime at the specified rate. Rice variety MR 219

was tested which is the most common variety grown in Malaysia right now. The result showed that soil pH was < 3.5 and exchangeable Al was very high throughout the soil depth. Water pH in the rice field before treatment was 3.7, while Al concentration was 878 µM. The first crop of rice was subjected to drought during the vegetative growth, while the subsequent crop was infested with rice blast. In spite of that, the results showed that application of 4 t GML ha^{-1} gave a reasonably good yield of 3.5 t ha^{-1}, the best among the treatments. The ameliorative effects of lime application had been continued into the second season. From this study, the suitable liming material to be used to alleviate acid sulfate soils at Merbok is 4 t ha^{-1} of GML costing about RM 1260.

Keywords: Rice (*Oryza sativa*), Acid Sulfate Soil, Aluminum toxicity, Liquid lime, Ground Magnesium Limestone

Abstrak thesis yg dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains Pertanian

MEMBAIKPULIH KEASIDAN TANAH ASID SULFAT MELALUI PENGAPURAN UNTUK PENANAMAN PADI DI SEMENANJUNG MALAYSIA

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Suatu kajian telah dijalankan di Merbok, Kedah, Malaysia. Kawasan kajian tersebut ialah kawasan penanaman padi di tanah asid sulfat diklasifikasikan sebagai Siri Merbok (*Typic Sulfaquents*). Tanah tersebut mengandungi kandungan Al yang tinggi. Sekitar 3000 ha tanah di Merbok, Kedah ditanam dengan padi, variety MR 219. Pada masa sekarang, penghasilan padi adalah kurang 2 t ha^{-1} $musim^{-1}$, di bawah paras national iaitu 2 t ha^{-1} $musim^{-1}$. Oleh itu, objektif kajian ini mencadangkan cara untuk menambah baik tanah asid sulphate di Merbok, Kedah, Malaysia. Kajian makmal, kajian rumah kaca dan kajian lapangan telah dijalankan.

Kajian pertama ialah kajian makmal. Objektif kajian ini adalah untuk menetukan kesan Al dan/atau pH ke atas pertumbuhan benih padi, morfologi akar dan perembesan asid organik. Benih padi (MR 219) dicambahkan berasingan dalam larutan 0.5 mM $CaCl_2$ dengan kepekatan Al yang berbeza (10, 20, 30, 40 dan 50

μM); dan dalam air yang diambil dari kawasan tanah asid sulfat Malaysia di mana pH diubah dengan menggunakan 0.01 M HCl atau NaOH. Hasil kajian menunjukkan pemanjangan akar berkurang dengan peningkatan kepekatan Al, manakala sebaliknya berlaku untuk pH. Perubahan bagi luas permukaan akar dengan kepekatan Al dan pH adalah sama seperti pemanjangan akar. Kepekatan kritikal Al bagi pertumbuhan padi adalah 15 μM manakala pH yang optima untuk pertumbuhan akar padi adalah 6. Pada pH yang rendah dan kepekatan Al yang tinggi, akar padi merembeskan citrat dan/atau oksalat yang akan membentuk Al-citrat dan Al-oksalat. Justeru, ini mengurangkan ketoksikan Al ke suatu tahap yang lebih rendah. Ini merupakan mekanisma toleransi padi terhadap ketoksikan Al.

Kajian kedua adalah kajian di rumah kaca. Objektif kajian ini adalah untuk menentukan kesan aplikasi kapur ke atas sifat kimia tanah dan pertumbuhan padi di bawah keadaan rumah kaca. GML dan *hydrated lime* diletakkan 2 minggu, manakala *liquid lime* diletakkan sehari sebelum penanaman padi; varaiti padi yang digunakan ialah MR 219. Didapati bahawa rawatan dengan menggunakan 4 t/ha *GML* memperolehi hasil padi tertinggi iaitu 8.2 t/ha dalam keadaan rumah kaca. Relatif hasil padi adalah berkadar songsang dengan pH tanah. Pada waktu menuai, pH tanah melebihi 6 bagi ke semua tanah yang dirawat dan ini menunjukkan tukargantian Ca meningkat dengan peningkatan pH tanah. Tanah yang dirawat dengan 2 t/ha *hydrated lime* memberikan tukargantian Ca tanah yang tinggi iaitu 11.86 $cmol_c$/kg tanah. Pada kadar ini, kepekatan Ca dalam akar adalah 0.12%

Kajian ketiga dijalankan di Merbok. Objektif kajian ini ialah meningkatkan hasil padi di atas tanah asid sulfat di bawah hujan semula jadi di Merbok, kedah, Malaysia

dengan menggunakan pelbagai jenis kapur. Tanah tersebut dirawat dengan menggunakan ground magnesium limestone, hydrated lime dan liquid lime pada kadar yang spesifik. Varaiti padi MR 219 digunakan iaitu varaiti yang biasa digunakan di Malaysia pada masa sekarang. Hasil kajian menunjukkan pH tanah adalah < 3.5 dan tukargantian Al adalah sangat tinggi mengikut kedalaman tanah. pH air sebelum rawatan adalah 3.7, manakala kepekatan Al ialah 878 µM. Tanaman padi pada musim pertama berhadapan dengan keadaan kemarau di peringkat vegetatif, manakala tanaman musim berikutnya diserang oleh karah padi. Oleh yang demikian, hasil kajian menunjukkan bahawa rawatan 4 t/ha *GML* memberikan hasil yang memberangsangkan iaitu 3.5 t/ha berbanding rawatan lain. Kesan pengapuran ini berlarutan sehingga musim kedua. Dari kajian ini, kapur yang sesuai untuk digunakan bagi membaik pulih tanah asid sulphate ialah 4 4 t ha^{-1} GML dengan kos RM 1260.

Kata kunci: Padi (*Oryza sativa*), Tanah asid sulfat, Keracunan aluminum, Liquid lime, Ground magnesium limestone

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APPROVAL 1

I certify that an Examination Committee has met on 24th April 2012 to conduct the final examination of **Elisa Azura bt Azman** on her **Master of Agricultural Science** thesis entitled **"Amelioration of soil acidity by liming for rice grown on an acid sulphate soil in Peninsular Malaysia"** in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulation 1981. The Committee recommends that the student be awarded the Master of Agricultural Science (Fertiliser Technology and Nutrient Management**).**

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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.

_____

ELISA AZURA AZMAN

Date: 24 April 2012

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