UNIVERSITI PUTRA MALAYSIA

ALLEVIATING SOIL ACIDITY USING BASALT FOR IMPROVEMENT OF RICE (Oryza sativa L.) YIELD GROWN IN AN ACID SULPHATE SOIL

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FP 2013 25

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

June 2013

DEDICATION

This thesis is dedicated

to my lovely husband Mohd Firdaus b. Abdul Razak and my beloved son

Muhammad Aqil Muslim b. Mohd Firdaus, my parents

Mohd Ali Raini b. Mohd Yusoff, Nurhani bt. Mohd Darus

and all my family members

thank you for the support and love.

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

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Chairman : Professor Shamshuddin Jusop, PhD

Faculty : Agriculture

Rice yield on acid sulfate soils in Malaysia is low, far below the national average of 3.08 t ha^{-1} $year^{-1}$, due to Al and/or Fe (ll) ion toxicity. Acid sulfate soil and sediments contain iron sulfides (FeS_2), the most common being pyrite. When exposed to the air due to drainage or disturbance, these soil produce sulfuric acid, which this make, the pH become low (≤3.5). Acid sulfate soil pose chemical, biological and physical problem to the crop. This study was conducted to ameliorate an acid sulfate soil in the Semerak- Kemasin Integrated Agriculture Development Project (IADP) located in Kelantan, Peninsular Malaysia, for rice cultivation using ground magnesium limestone (GML), and ground basalt.

An incubation study was conducted in the glasshouse to alleviate the infertility of an acid sulfate using basalt with or without ground magnesium limestone (GML). Fresh soils were treated with the amendments and some microorganisms than subjected to two cycles of submergence (4 months) and drying (2 months). After every 4 months of submergence the soil and solution were taken for the analysis. The untreated soil

pH was 3.44 (<3.5) and exchangeable Al in the soil was high (5.36 $cmol_c\ kg^{-1}$). GML application at 4 t ha^{-1} was able to increase pH and subsequently, reduced Al toxicity for rice growth. After 4 months of submergence, solution pH of the sample treated with 4 t basalt ha^{-1} had increased from 3.61 to 3.94, with concomitant decrease of Al. In the same cycle, soil pH increase was much higher (5.22). Basalt is thus deduced as comparable to GML as an acid soil ameliorant. Within the experimental period, basalt had mostly disintegrated and dissolved. The solution pH had further increased (5.94) in the 2nd cycle due to dissolution of more basalt. This means that it takes time for basalt to completely dissolve and consequently supply Ca, Mg, K and P to the growing crop in the field.

Basalt application is only good for a long- term solution for acid sulfate soil infertility. Another glasshouse study was conducted using the same type of acid sulfate soil in which rice was used as the test crop. This study was conducted in order to determine the effects of applying ground basalt on the chemical properties of an acid sulfate soil and the growth of rice. GML as command amendment used by farmer in Malaysia as a liming material, so that, GML were use to compared the effectiveness of basalt as a liming material. Statistical analysis show there are no significant different between 4 t GML ha^{-1} (T2= 4.21 t ha^{-1}) and 4 t basalt ha^{-1} (T4= 4.41 t ha^{-1}) on rice yield. The low fertility of the soil can be effectively ameliorated by applying 4 t ground basalt ha^{-1} and improve the rice yield grown in an acid sulfate soil. This study showed the clear benefit of ground basalt as an amendment for acid sulfate soil infertility. This is comparable to that of applying 4 t GML ha^{-1}, which is the standard lime requirement of acid sulfate soil in Malaysia. Basalt takes time to dissolve completely. The best option is therefore to apply ground basalt in few

months before rice is transplanted in the field. Basalt application has other advantage by way of supplying Si needed by rice for its maximal growth.

Basalt application had increased solution and soil pH. This resulted in the precipitation Al as Al- hydroxide. Basalt contains Ca, Mg, K, P and S. The dissolution would provide the macronutrients to the growing rice in the pots. Furthermore, the presence of extra Ca in the treated soils had somewhat alleviated Al toxicity. Only N is absent in basalt. The hydrolysis of the silicate released by the olivine not realized carbon dioxide CO_2 which is the principal greenhouse gas compared to hydrolysis of CaMg $(CO_2)_2$ produce by GML. This excess released of CO_2 will promote into climate changes. Though, GML is the best liming material to increased the pH and lowering the Al concentration in an acid sulfate soil, but in other hand, basalt also have a big potential to be another alternative as liming material, basalt as because of the cost is low, RM 30 per ton compared to GML which is RM 165 per ton. Basalt application by famers will reduce the rice plantation cost.

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

MENGURANGKAN KETIDAKSUBURAN TANAH ASID SULFAT UNTUK TANAMAN PADI (*Oryza sativa L.)* DENGAN MENGGUNAKAN BASALT

Oleh

SITI SHAZANA BINTI MOHD ALI RAINI

Jun 2013

Pengerusi : Profesor Shamshuddin Jusop, PhD

Fakulti : Pertanian

Hasil padi rendah apabila ditanam di atas tanah asid sulfat kerana ketoksidan ion Al dan/atau Fe(II). Tanah asid sulfat mengandungi ferum sulfida (FeS_2), kebiasaannya dipanggil pirit. Apabila pirit terdedah kepada udara yang di sebabkan oleh saliran atau pun gangguan, tanah in akan membentuk asid sulfurik yang memnyebabkan pH tanah menjadi rendah (≤3.5) dan membebaskan bahan toksik seperti Fe(II), Al dan logam berat. Tanah asid sulfurik, akan menyebabkan masalah kimia, biologi dan fizikal kepada tumbuhan. Ujikaji ini dijalankan untuk membaikpulih tanah asid sulfat di kawasan Pembangunan Pertanian Bersepadu di bawah Projek Kemasin- Semerak (PERKASA) di Kelantan, Semenanjung Malaysia , untuk penanaman padi dengan menggunakan GML, dan basalt.

Kajian pemeraman adalah untuk mengurangkan ketaksuburan tanah asid sulfat dengan menggunakan basalt dengan atau tanpa GML. Tanah dirawat dengan bahan-bahan tambahan tadi kemudian diperam selama 2 kali pusingan, tanah direndam dan

kemudian dikeringkan. Tanah yang tidak dirawat mempunyai pH tanah < 3.5 dan Al didalam larutan adalah tinggi. Penggunaan GML pada kadar 4 t ha^{-1} meningkatkan pH tanah dan sekaligus menurunkan toksikan Al untuk penanaman padi. Selepas 4 bulan tanah direndam, pH larutan yang dirawat dengan 4 t ha^{-1} basalt meningkat daripada 3.61 kepada 3.94, dan menurunkan kandungan Al. Pada pusingan yang sama, pH tanah meningkat lebih tinggi (5.22). Basalt adalah setanding dengan GML sebagai tanah pemuliharaan. Dalam jangkamasa ujikaji, kebanyakan basalt terhurai dan terlarut. pH larutan semakin meningkat (5.94) pada pusingan kedua berdasarkan lebih banyak basalt yang terhuarai. Ini membuktikan basalt mengambil masa yang panjang untuk terhurai sepenuhnya dan menghasilkan Ca, Mg, K dan P untuk tumbuhan di ladang.

Penggunaan basalt adalah hanya baik untuk meyuburkan tanah asid sulfat bagi penyelesaian jangka panjang. Ujikaji di rumah kaca dilakukan dengan menggunakan tanah asid sulfat yang sama dan padi digunakan sebagai tanaman ujian. Ujikaji ini dijalankan untuk menguji keberkesanan basalt terhadap sifat kimia tanah asid sulfat dan pertumbuhan padi. GML adalah bahan yang utama digunakan utuk mengapur tanah di Malaysia, jadi GML digunakan untuk membandingkan keberkesanan basalt sebagai bahan perkapuran. Menurut kajian statistik, tiada bezanya antara kedua- dua bahan iatu GML dan basalt terhadap hasil padi yang terhasil 4 t ha^{-1} GML (T2= 4.21 t ha^{-1}) dan 4 t basalt ha-1 (T4= 4.41 t ha^{-1}). Tanah asid yang tidak subur boleh dibaikpulih dengan menggunakan 4 t basalt ha^{-1}. Ujikaji ini membuktikan kebaikan basalt sebagai bahan pembaikpulih ketida ksuburan tanah asid sulfat. Perbandingan ini dibuat dengan aplikasi 4 t GML ha^{-1}, iaitu keperluan piawai pengapuran pada tanah asid sulfat di Malaysia.. Hasil ini tidak menunjukkan perbezaan bagi tanah yang

dirawat dengan 4 t GML ha^{-1} sahaja atau tanah yang dirawat denagn 4 t basalt ha^{-1} sahaja. Basalt mengambil masa untuk larut sepenuhnya. Pilihan terbaik adalah dengan menggunakan basalt beberapa bulan sebelum padi di tanam di sawah. Selain itu, penggunaan basalt mempunyai kelebihan dalam memperuntukan keperluan Si kepada padi untuk pertumbuhan maksimum.

Penggunaan basalt dapat meningkatkan pH larutan dan pH tanah. Ini adalah kerana pemendakan Al kepada Al- hidroksida. Basalt menganduni gi Ca, Mg, Ka, P dan S. Pemerlarutannya akan menghasilkan makronutrien untuk pertumbuhan padi di dalam tanki. Selain itu, Ca yang berlebihan yang terhasil dapat mengurangkan ketoksikan Al. Hanya N sahaja yang tidak terkandung didalam basalt. Proses penurunan silikit debebaskan dari olivine tidak membebaskan CO_2, iaitu penyumbang terbesar kepada gas rumah hijau dibandingkan dengan penurunan oleh $CaMg(CO_2)_3$ yang dihasilkan daripada GML. Gas CO_2 yang berlebihan terbebas akan menyumbang kepada kesan perubahan cuaca. Walaupun, GML terbukti berkesan sebagan bahan pengapuran pada tanah asid sulfat, tetapi basalt juga ada potensi sebagai bahan pengapuran altenatif kerana kosnya rendah berbanding GML, kos basalt adalah RM 30 per tan, manakala GML aadalah Rm 165 per tan. Pengguanaan basalt sebagai bahan pengapuran akan merendahkan kos penanaman padi di Malaysia.

ACKNOWLEDGEMENTS

"In the Name of Allah, the Most Gracious and Most Merciful**".** Peace and blessings of Allah be upon Prophet Muhammad. Praised be to Allah SWT, with His grace I am able to complete this thesis. Special appreciation and gratitude are extended to my conscientious and caring advisor, Professor Shamshuddin Jusop. His perpetual energy, wide knowledge and enthusiasm in research had greatly motivated me. The material and financial support from Prof Shamshuddin is gratefully acknowledged. I was delighted to interact with Associate Professor Dr Che Fauziah Ishak , Deputy Dean (Academic, Student's Affairs and Alumni) Faculty of Agriculture, UPM and having her as my co-supervisor. I am deeply grateful to her for her detailed and constructive comments, and for her invaluable support throughout this work.

I would like to thank the Department of Land Management Universiti Putra Malaysia (UPM) for providing the research facilities. Thanks also to UPM for awarding graduate research fellowship and Ministry of High Education Malaysia (MOHE) for supporting me in paying my tuition fees and the Low-term Research Grant Scheme (LRGS) funding for the financial support, Persatuan Pertubuhan Perladang Tanjung Karang, Selangor, for providing rice seedlings (MR 219) and the Kemasin- Semerak Integrated Agriculture Development Project (IADP), Kelantan for providing the soil for the glasshouse experiment.

Sincere thanks and appreciation are also extended to all Department of Land Management staff, Faculty of Agriculture, especially Mr Alias Tahar, Mr Asri Ruslan Abd. Ghani, Mrs Rosnah Ajis, Mr. Jamil Omar, Mrs Zarina Basir and Mrs Zabedah

for their valuable help and cooperation during experiment. Thanks are addressed to staff at Microscopy Unit, Institute of Bioscience, UPM for being so friendly and helpful. I wish to thank also to my fallow friends in Mineralogy Laboratory, Ms Elisa Azura, Ms Norkhatina, Mrs Rosilawati, Ms Malisa, Ms Enio Kang, Ms Syuhada and Mr Roslan for always helping me in time of hardship.

My deepest gratitude goes to my family for their unwavering love and support throughout my life. The two people I would like to express my deepest appreciation to, for their love and support, are my beloved mother and father. My beloved mother, Nurhani Mohd Darus, I will always remembers all your humble life, patience and courage that had inspired me. My beloved father, Mohd Ali Raini Mohd Yusoff is my hero and is always there when I need help and he always remain as a source inspiration in my life. Finally, my deepest gratitude is extended to my beloved husband Mohd Firdaus Abdul Razak, for his patience, continuous support, understanding and encouragement.

I certify that the Examination Committee had met on 8 June to conduct the final examination of Siti Shazana Binti Mohd Ali Raini on her thesis entitled "Alleviating Soil Acidity using basalt for Improvement of Rice *(Oryza Sativa L.)* Yield Grown in Acid Sulfate Soil" in accordance with 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 follows:

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This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirements for the degree of Master of Science. The members of the Supervisory Committee are as follows:

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DECLARATION

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

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SITI SHAZANA BINTI MOHD ALI RAINI

Date: 8 June 2013

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