UNIVERSITI PUTRA MALAYSIA

PERFORMANCE OF SODIUM PENTABORATE AND COLEMANITE AS SOURCES OF BORON FOR RICE GROWN ON ACID AND CALCAREOUS SOILS

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FP 2010 15

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By

SALEEM MUHAMMAD

Thesis submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy
September 2010

DEDICATION

THIS WORK IS DEDICATED TO MY PARENTS FOR THEIR NEVER ENDING PRAYERS AND SPIRITUAL SUPPORT WHICH ALWAYS ACT AS A CATALYST IN MY ACADEMIC LIFE. I ALSO DEVOTE THIS HUMBLE EFFORT TO MY DEAR WIFE MANZOORAN AND CHILDREN MUHAMMAD WASEEM, MUHAMMAD TAUHEED, MARIA, TANIA AND SANIA. THEY HAVE LOST A LOT DUE TO MY RESEARCH ABROAD. WITHOUT THEIR SUPPORT AND UNDERSTANDING, IT WOULD HAVE BEEN IMPOSSIBLE FOR ME TO FINISH THIS WORK.

Abstract of the thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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September 2010

Chairman: Professor Mohd Khanif Yusop, Ph.D

Faculty : Agriculture

Boron deficiency is the most common and widespread micronutrient deficiency problem, which impairs plant growth and reduces yield. Rice is a major staple food of Asia and to keep pace with population growth, rice yields should be increased. Hence a comprehensive study was initiated to determine the soil B status in soils of the flooded rice cultivated in tropical area of Malaysia and to investigate the effectiveness of different B fertilizer sources and application rates on supplying adequate quantity of B for rice plant. Boron status study was conducted by collecting and analyzing soil samples from 15 soil series of paddy growing areas in Kedah and Kelantan states of Malaysia. Three forms of B fertilizers sodium pentaborate (SP), powder colemanite (PC) and granular

colemanite (GC) were screened for their suitability as B fertilizers for flooded rice crops under acidic and calcareous soils. The effectiveness of three B fertilizers were assessed for their dissolution kinetic rates at different pH levels, B release in soil under soil incubation study and B leaching losses by conducting experiment in uniform packed soil columns. Field experiments was conducted near Alor Setar, Kedah. Four B levels (0, 1, 2, 3 kg B ha^{-1}) in the form of SP, PC and GC were applied on rice. This experiment was continued for a second season to study the residual effect of B fertilizers on subsequent rice crop. A glasshouse experiment similar to field experiment was also conducted under high pH calcareous soil. The results indicated that the soils of paddy growing areas were very low in B status. All the soils of 15 series have available B below 0.5 mg kg^{-1} irrespective of depth and locations. Dissolution kinetics, soil incubation and soil column studies showed that dissolution rate of SP was higher than the other two fertilizers and pH did not have any effect on dissolution rate. There was no difference in quantity of B release from SP and PC after few weeks of application. Boron leaching losses from SP were higher than from PC and GC. Dissolution rate and solubility of GC was very slow in comparison to PC. Results of field experiment showed that application of SP and PC at 3 kg B ha^{-1} improved all plant growth parameters, B concentration in spikelet and rice yield over the control and other B rates. There was no yield difference in SP and PC applied plots but GC had not shown any effect on rice growth and yield. Results of our second field experiment showed that effect of residual SP, PC and GC at 3 kg B ha^{-1} significantly increased the plant growth and spikelet yield over the control. There was no significant difference in yield between plots with

residual SP and PC fertilizers but their yields were significantly higher than plots with residual GC. The results of the glasshouse experiment under calcareous soil showed that SP and PC application at 3 kg B ha^{-1} produced higher yield than the 1 and 2 kg B ha^{-1} and there was no yield difference between ST and PC applied pots. However, application of GC had not increased the yield. Overall, results of our studies showed that Malaysian soils of paddy growing areas were deficient in available B status. SP was readily soluble and colemanite was slow release fertilizer. Sodium pentaborate and PC application significantly increased rice yield under flooded acidic and calcareous soils. Results of the study showed strong evidence of the positive residual effects of B on rice crop yield. There was no yield difference between SP and PC applied plots, both fertilizers were equally effective B sources. It was also observed that GC was ineffective B source due to non-solubility.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagi memenuhi keperluan untuk ijazah Doctor Falsafah

PRESTASI SUMBER BORON SODIUM PENTABORATE DAN COLEMANITE DALAM TANAH BERASID DAN BERKAPUR UNTUK PADI

Oleh

SALEEM MUHAMMAD

September 2010

Pengerusi : Professor Mohd Khanif Yusop, Ph.D

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Kekurangan boron adalah masalah kekurangan mikronutrien yang paling umum dan meluas, yang mengganggu pertumbuhan tanaman dan mengurangkan hasil. Nasi adalah makanan utama orang Asia dan untuk mengimbangi pertumbuhan penduduk, hasil padi harus ditingkatkan. Oleh kerana itu satu kajian menyeluruh telah dimulakan untuk menentukan status B dalam tanah sawah padi di Malaysia dan untuk mengkaji keberkesanan perlbagai jenis sumber baja B serta kadar applikasi untuk membekalkan kuanti B yang mencukupi bagi pertumbuhan padi dan dalam masa yang sama mengurangkan larut lesap. Kajian status B dijalankan dengan mengumpul dan menganalisa sampel tanah dari 15 siri tanah dari kawasan padi di Kedah dan Kelantan, Malaysia. Tiga bentuk baja B; sodium pentaborate (ST), colemanite serbuk (CS) dan colemanite granular (CG) disaring untuk menentukan kesesuaian mereka

sebagai baja B untuk tanaman padi di tanah keadaan asid dan berkapur. Keberkesanan baja ini dinilai berdasarkan kepada kadar kinetik disolusi pada tahap pH yang berbeza, pengeluaran B dalam tanah di bawah kajian inkubasi tanah dan kehilangan melalui larutlesap dengan melakukan eksperimen di kolum tanah yang dikemas secara seragam. Kajian lapangan dilakukan menggunakan empat tahap B (0, 1, 2, 3 kg B ha^{-1}) dalam bentuk SP, CS dan CG di tanah berasid yang kekurangan B. Penelitian ini disambung ke musim kedua untuk melihat kesan pengaruh residu baja ini. Eksperimen yang dilakukan di lapangan ini di jalankan semula di rumah kaca tetapi menggunakan tanah berkapur. Walaubagaimanapun, kajian tentang kesan residu baja keatas pertumbuhan pokok padi tidak dilakukan. Keputusan menunjukkan bahawa tanah satus B di kawasan yang ditanami padi sangat rendah. Semua 15 siri tanah tanpa mengira lokasi dan kedalaman mempunyai kandungan B di bawah 0.5 mg kg^{-1}. Kajian disolusi kinetic, inkubasi tanah dan kolum tanah menunjukkan kadar disolusi boraks lebih tinggi berbanding dengan dua baja yang lain dan pH tidak mempunyai kesan pada kadar disolusi, tiada perbezaan kuantiti B yang dilepaskan dari SP dan CS setelah beberapa minggu diapplikasikan. Kehilangan B melalui larutlesap dari SP lebih tinggi dari CS dan CG. Kadar disolusi dan kelarutan CG adalah amat perlahan dibandingkan dengan CS. Keputusan ujikaji di lapangan menunjukkan bahwa kadar applikasi SP dan CS pada 3 kg B ha^{-1} meningkatkan semua parameter tumbesaran tanaman, kepekatan B dalam buah padi dan hasil padi berbanding kawalan dan kadar B yang lain. Tiada perbezaan hasil antara plot yang diaplikasi dengan SP dan CS tetapi CG tidak member sebarang kesan kepada tumbesaran dan hasil

padi. Keputusan dari ujikaji lapangan yang kedua menunjukkan bahawa kesan residu B dari SP, CS dan CG pada kadar 3 kg B ha^{-1} meningkatkan tumbesaran dan hasil tanaman dengan ketara berbanding kawalan. Tiada perbezaan ketara dari segi hasil tanaman di antara plot yang mempunyai residu SP dan CS tetapi hasil dari kedua-dua plot ini adalah lebih tinggi dan ketara berbanding plot yang mempunyai residu CG. Keputusan ujikaji di rumah kaca menggunakan tanah berkapur menunjukkan SP dan CS pada kadar 3 kg B ha^{-1} menghasilkan hasil yang lebih tinggi berbanding kadar 1 dan 2 kg B ha^{-1} serta tiada perbezaan hasil antara plot yang diaplikasi dengan SP dan CS. Namun, aplikasi CG tidak meningkatkan hasil. Secara keseluruhan, keputusan kajian kami menunjukkan bahawa tanah yang ditanam dengan padi di Malaysia kekurangan dari segi status B yang kedapatan. Sodium pentaborate lebih larut manakala colemanite adalah baja pelesapan perlahan. Aplikasi SP dan CS meningkatkan hasil padi pada tanah terendam berasid dan berkapur secara ketara. Residu SP dan CS meningkatakn hasil pada pada musim ke dua secara ketara. Tiada perbezaan hasil di antara plot yang diaplikasi dengan SP dan CS, kedua-dua baja adalah sama berkesan sebagai sumber B. Dapat dilihat juga bahawa CG tidak berkesan sebagai sumber B kerana ketidaklarutannya.

ACKNOWLEDGEMENT

I wish to express my profound gratitude to my research supervisor Professor Dr. Mohd Khanif Yosup, Department of Land Management, Universiti Putra Malaysia for his guidance, co-operation, constructive criticism, encouragement and kind supervision during the entire course of the study. He showed me different ways to approach a research problem and the need to be persistent to accomplish any goal. I owe my most sincere gratitude to Associate Professor Dr. Che Fauziah Ishak and Dr. Samsuri Abd Wahid, for their valuable suggestions and guidance through all these years in conducting research and writing of manuscripts.

Besides my supervisors, I would like to gratefully acknowledge the support of Mr. Alias Tahir and Mrs Umi Kalthum, during the field experiments and laboratory analyses. My heartiest thanks to lab mates and friends Hafeezullah Babar, Amjad Ali, Kiran, Kala Devi, Fazlyna, Abdul Samad, Velo Suthar, Khalil Dharejo and Alagie for their cooperation and encouragement. I am also grateful to the Agriculture Department Government of Sindh, Pakistan for providing financial support during the course of this work, at Universiti Putra Malaysia. Last but not least, my great thanks goes to my relatives and friends back in Pakistan for their encouragement and moral support in conducting and accomplishing my research work.

I certify that and Examination Committee has met (on date of viva) to conduct the final examination Saleem Muhammad on his thesis entitled “Evaluation of Rice Genotypes for adoptability to Zinc Deficient 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 Doctor of Philosophy.

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This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotation 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 other institutions.

SALEEM MUHAMMAD

Date: 27 September, 2010

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