UTILIZATION OF SEAWATER FOR PINEAPPLE CULTIVATION

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DOCTOR OF PHILOSOPHY
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By

MUHAMMAD PRAMA YUFDY

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

March 2004

Dedicated to

my Parents:
H. Meigoes Maaroef and
Hj. Noer Joesnar,
my wife Hayani
my children:
Muhammad Fajar Anandi
Utami Mardhiyah Dinanti
Atiya Nur Ramadhani

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

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March 2004

Chairman: Associate Professor Ahmad Husni Mohd. Hanif, Ph.D.

Faculty : Agriculture

Pineapple needs a large amount of potassium (350 kg K ha^{-1}), which is higher than the other nutrient requirements. As a crassulacean acid metabolism species, it also requires some amount of Na as a beneficial nutrient to replace part of potassium's function. This provides an opportunity to decrease K fertilizer cost, especially for non-K fertilizer producer countries such as Malaysia where the import bill for K fertilizer is the highest compared to N and P fertilizers. A readily available source of Na is seawater, which contains about 4,000-10,000 mg L^{-1} Na. Three experiments were conducted to study the possibility of utilizing nutrients from seawater. The first experiment was to observe sorption and desorption of K, Na, Ca and Mg from different concentrations of seawater in natural zeolite. The second and third experiments were to study the extent to which Na could replace the function of K in pineapple. The results indicated that natural zeolite could sorb Na, Mg and K from

seawater. The highest sorption for Na, Mg and K was from 40% diluted seawater at 2260.00, 210.00 and 60.00 μg g^{-1} zeolite, respectively. The cations were then desorbed from zeolite cavities. As a slow release agent of cations, zeolite treated with 20% seawater released 576.67 and 102.33 μg g^{-1} zeolite of Na and Mg, respectively. Application of Na for K substitution (0, 15, 30 and 60%) from seawater and NaCl in a Bungor Series of Typic Paleudult soil resulted in no significant increase in soil pH, CEC, EC and turbidity. Sodium uptake in D-leaf increased significantly up to 30% Na for K substitution (diluted seawater) and 60% Na for K substitution (NaCl) without any toxic effect to the plant. The highest plant dry weight (3.45 kg) was obtained from 30% Na for K substitution using diluted seawater. However, there was no significant difference among all treatments for fresh fruit weight. Similar results in soil properties and Na uptake were also found in a more detailed study conducted in a Seremban Series of Plintic Kandiudult soil. Application of diluted seawater, NaCl, and seawater-zeolite effluent decreased plant dry weight which can be attributed to decreasing cell membrane stability as an indication of toxicity due to increasing Na in plant tissue for 60% Na for K substitution. However, sodium application induces thicker water storage tissue in D-leaf, which may be an adaptation response of pineapple to increased Na. In general, the results of the study indicated that zeolite can sorb and desorb Na, Mg and K; and 30% of pineapple K requirement (in term of fertilizer application) can be replaced by Na from diluted seawater, NaCl, zeolite saturated with seawater and seawater-zeolite effluent, and the rest (70%) from K fertilizer.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

**PEMANFAATAN AIR LAUT
UNTUK PENANAMAN NENAS**

Oleh

MUHAMMAD PRAMA YUFDY

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Pengerusi: Profesor Madya Ahmad Husni Mohd Hanif, Ph.D.

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Nenas memerlukan jumlah kalium yang banyak (350 kg K ha^{-1}) berbanding dengan jenis nutrien yang lain. Sebagai spesis *crassulacean acid metabolism*, nenas memerlukan sedikit Na untuk menggantikan sebahagian fungsi K. Ini memberi peluang bagi pengurangan kos baja K, terutama untuk negara bukan pengeluar baja K seperti Malaysia, dimana kos untuk baja ini adalah paling tinggi. Salah satu sumber Na yang tersedia ialah air laut yang mengandungi 4,000 hingga 10,000 mg L^{-1} Na. Tiga uji kaji telah dilakukan untuk mengkaji kemungkinan memanfaatkan nutrien yang berasal daripada air laut. Uji kaji pertama mengkaji penyerapan dan pengeluaran baja dari air laut menggunakan zeolit. Uji kaji kedua dan ketiga adalah untuk mengkaji berapa banyak Na yang dapat menggantikan fungsi K pada nenas. Hasil uji kaji menunjukkan bahawa zeolit dapat menyerap Na, Mg dan K daripada air laut. Keupayaan penyerapan maksima maing-masing adalah 2260.00, 210.00 and 60.00

µg g^{-1} zeolit untuk Na, Mg dan K dari 40% air laut dicairkan. Kation tersebut kemudian dapat dikeluarkan dari zeolit secara perlahan. Zeolit yang diberi 20% air laut dicairkan dapat mengeluarkan baja Na dan Mg sebanyak 576.67 and 102.33 µg g^{-1} zeolit. Aplikasi Na bagi menggantikan fungsi K (0, 15, 30 dan 60%) dari air laut dan NaCl pada tanah Typic Paleudult (Siri Bungor) menunjukkan tiada kesan kepada pH, keupayaan kation tukar ganti dan kekeruhan. Pengambilan Na pada daun D meningkat pada konsentrasi 30% Na bagi menggantikan fungsi K (untuk air laut) dan 60% (pada NaCl) dan tiada sebarang kesan toksik pada tanaman nenas. Berat kering tanaman paling tinggi (3.45 kg) diperolehi dari 30% Na bagi menggantikan fungsi K (untuk air laut). Hasil diperolehi tidak berbeza nyata untuk berat buah segar nenas pada kesemua rawatan. Hasil yang sama terhadap tanah dan pengambilan Na diperolehi juga pada uji kaji yang lebih terperinci pada tanah Plintic Kandiudult (Siri Seremban). Berat kering tanaman pada rawatan air laut dicairkan, NaCl dan cecair air laut-zeolit menurun pada rawatan 60% Na bagi menggantikan fungsi K. Hasil tersebut berkait rapat dengan penurunan kestabilan membran sel pada semua rawatan. Ini boleh menjadi petunjuk ketoksikan tanaman nenas kerana meningkatnya paras Na di dalam tanaman. Aplikasi Na meningkatkan ketebalan tisu penyimpan air pada daun D, hal ini berkemungkinan merupakan tindakbalas daripada penyesuaian pokok nenas keatas Na. Hasil uji kaji menunjukkan bahawa zeolit dapat menyerap Na, Mg dan K daripada air laut dan dikeluarkan secara perlahan; 30% keperluan baja K pada tanaman nenas dapat diganti dengan Na dari air laut dicairkan, NaCl, zeolit yang ditepukan dengan air laut, dan cecair air laut-zeolit dan bakinya daripada baja K.

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I certify that an Examination Committee met on 15 March 2004 to conduct the final examination of Muhammad Prama Yufdy on his Doctor of Philosophy thesis entitled "Utilization of Seawater for Pineapple Cultivation" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citation which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institution.

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MUHAMMAD PRAMA YUFDY

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