UNIVERSITI PUTRA MALAYSIA

POTASSIUM REQUIREMENT OF MATURE OIL PALM ON COASTAL SOILS

MOHAMAD HASHIM AHMAD TAJUDIN

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Abstract of dissertation submitted to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the Degree of Doctor of Philosophy

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MOHAMAD HASHIM AHMAD TAJUDIN

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Chairperson : Associate Professor Zaharah Abdul Rahman, Ph.D.

Faculty : Agriculture

Oil palm grown in the coastal marine clay soils are very productive with fresh fruit bunches (FFB) yield ranging between 28-40 tonnes per hectare. The high yield is attributable to high yielding planting materials, good agronomic practices and sound fertilizer application programme. Of the three factors, fertilizer application is considered to be the most influencing factor in maintaining high yield. In oil palm nutrition, the main nutrients which are important for vegetative growth and production are nitrogen, phosphorus, potassium and magnesium. However, the responses of oil palm to potassium fertilizer application on coastal marine clay soils are low and varied between and within the soil series. There is no clear answer to this phenomenon and thus this study was undertaken to provide explanation on the potassium requirements of oil palm planted on coastal marine clay soils.

In this study a series of trials were conducted. In the experiment studying the responses of mature oil palm to NPK fertilizer application, the results showed that application of NPK fertilizers significantly increased their respective nutrient levels in the pinnae, but the magnesium levels were not affected. On fresh fruit bunch (FFB) production, phosphorus and nitrogen fertilizer application recorded positive significant responses. On the other hand, potassium fertilizer application showed no relationship at all with FFB production.

In the experiment studying the responses of oil palm to potassium fertilizer application, the results of experiments indicated that potassium fertilizer application had significantly increased the potassium levels in the rachis and petiole and to a small degree in the pinnae, but this did not result in a corresponding increase in vegetative growth and crop production. Trunk analysis also showed high potassium content with increasing rate of potassium fertilizer application. The high potassium levels in the vegetative parts as a result of potassium fertilizer application were excess uptake because such high levels of potassium did not result in improved crop production. Such excess uptake was considered as luxury consumption.

In the experiment studying root distribution, it was confirmed that there was extensive root system of oil palm planted on coastal clay soils. Thus isolation trenches and guard rows were put in place right from the commencement of the experiments to prevent poaching of nutrients by oil palm roots from one treatment to another. Experiments using Rb-86 and K-42 isotopes also provided information indicating movement of potassium in the soil column. But the precautionary measures taken in the experiment layout had alleviated of the concern of drain water with potassium flowing from the potassium fertilized treatments to the unfertilized areas.

In the experiment studying the nutrient status of palms which were unfertilized for fifteen years, the results showed that the levels of potassium in pinnae, petiole, rachis and trunk were comparable to the regularly fertilized palms. However, the levels of nitrogen and phosphorus were very low with poor vegetative growth and unproductive. Thus oil palm when left unfertilized with nitrogen and phosphorus for an extended period would suffer badly in term of vegetative growth and production levels.

In view of the fact that the levels of potassium in the unproductive and unfertilized palms were comparable to palms receiving regular fertilizer application with good cropping levels, it is evident that bunch production was not entirely dependent on potassium inputs. Potassium would be required in a minimum quantity that was adequate for the basic biochemical functions of the palms. Adequate availability of nitrogen and phosphorus would thus seem to be more important for the production of bunches in the presence of just sufficient quantity of potassium for essential physiological processes. The biophysical functions of maintaining turgor pressure of the cell were complemented by other cations because of the fact that other cations such as magnesium and calcium were taken up in higher concentration in the palms planted on coastal soils. Their uptake in the palms was dependent on the availability of the respective cations in the soil. In situation when one cation was taken up in higher concentration, the other cations uptake would be lowered and vice-versa. As such, the total bases in the palms as indicated in the pinnae would remain consistent irrespective of which cations were taken more than the others. Such phenomenon is termed as complementary cationic relationship for the purpose of ensuring balanced cation levels in the oil palm system.

From the results of this study, it is clear that the potassium requirements of oil palm planted on marine coastal clay soils could be met by the soil reserve and potassium fertilizer application would not have any positive impact on FFB yield. The potassium taken up from the soil reserves was sufficient to support the oil palm potassium needs for the biochemical and partly the biophysical functions and thus, no further potassium fertilizer application was required for satisfactory growth and crop production.

Abstrak dissertasi yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Doktor Falsafah

KEPERLUAN KALIUM BAGI POKOK SAWIT MATANG DI TANAH-TANAH LANAR LAUT

Oleh

MOHAMAD HASHIM AHMAD TAJUDIN

Mei, 1999

Pengerusi : Profesor Madya Zaharah Abdul Rahman, Ph.D.

Fakulti : Pertanian

Kelapa sawit yang ditanam di tanah dataran pantai sememangnya mengeluarkan hasil buah tandan segar (BTS) yang tinggi dan dianggarkan dalam lingkungan 28-40 metrik tan sehektar. Pengeluaran BTS yang tinggi ini disebabkan oleh kegunaan benih yang berpotensi tinggi, amalan agronomi yang baik dan pembajaan yang sempurna. Daripada ketiga faktor ini, pembajaan dianggapkan paling berpengaruh untuk menentukan kelapa sawit terus mengeluarkan hasil yang tinggi. Dalam aspek pembajaan, nutrien yang utama diperlukan untuk pertumbuhan dan pengeluaran hasil kelapa sawit ialah nitrogen, fosforus, kalium dan magnesium. Walau bagaimanapun, kesan pembajaan kalium terhadap kelapa sawit di tanah-tanah lanar laut adalah rendah dan tidak menentu. Tidak ada penjelasan yang kukuh untuk menghuraikan keadaan sedemikian dan dengan itu kajian ini dijalankan untuk memberi penjelasan lanjut mengenai keperluan kalium bagi kelapa sawit yang ditanam di tanah-tanah lanar laut.

Dalam kajian ini beberapa siri eksperimen dijalankan. Dalam eksperimen mengkaji kesan pembajaan NPK kepada kelapa sawit matang, keputusannya menunjukkan bahawa pembajaan NPK telah meningkatkan tahap nutrien-nutrien ini di dalam daun, jentu pelepah dan gagang pelepah manakala tahap magnesium tidak terjejas. Pengeluaran BTS pula, dipengaruhi oleh nitrogen dan fosforus. Sebaliknya, kalium langsung tidak ada hubungan dengan pengeluaran BTS.

Dalam eksperimen mengkaji kesan pembajaan kalium kepada pokok sawit, keputusan kajian menunjukkan pembajaan kalium telah meningkatkan tahap kalium di dalam jentu pelepah dan gagang pelepah manakala pada daun ia menunjukkan peningkatan tetapi tidak terdapat peningkatan tumbesaran pokok dan hasil pengeluaran BTS. Analisis sampel batang pokok juga menunjukkan peningkatan tahap kalium ekoran pembajaan kalium. Tahap kalium yang tinggi di dalam bahagian vegetatif kelapa sawit ekoran pembajaan kalium adalah satu pengambilan nutrien secara berlebihan kerana tahap kalium yang tinggi ini tidak menghasilkan peningkatan pengeluaran BTS. Keadaan begini bolehlah ditafsirkan sebagai pengambilan yang berlebihan.

Analisis tanah yang dilakukan di dalam eksperimen-eksperimen ini telah mengesahkan kedapatan kalium yang tinggi di dalam tanah. Begitu juga dengan magnesium dan kalsium, dimana ianya dapat membekal kation-kation ini untuk diambil oleh kelapa sawit dengan cukupnya.

Dalam eksperimen mengkaji taburan akar pokok sawit, didapati taburan sistem akar memang begitu meluas bagi kelapa sawit yang ditanam di tanah-tanah lanar laut. Jadi, parit pengasingan dan barisan pokok-pokok penghalang telah disediakan sejak eksperimen dijalankan untuk menghindarkan kesan 'poaching' ke atas nutrien oleh akar kelapa sawit diantara rawatan. Eksperimen menggunakan isotop Rb-86 dan K-42 juga telah memberi maklumat yang menunjukkan pergerakan kalium di dalam tanah. Tetapi dengan langkah-langkah tertentu pada tapak kajian telah mengenepikan kebimbangan mengenai air parit yang mengandungi kalium mengalir dari rawatan yang dibaja dengan kalium ke kawasan tanpa pembajaan kalium.

Dalam eksperimen mengkaji status nutrien di dalam pokok sawit yang telah tidak dibaja selama lima belas tahun, hasil kajian menunjukkan tahap kalium di dalam daun, jentu pelepah, gagang pelepah dan batang adalah sama seperti kelapa sawit yang sentiasa menerima pembajaan. Walau bagaimanapun, tahap nitrogen dan fosforus adalah terlalu rendah dengan keadaan tumbesaran yang juga rendah serta tidak produktif. Ini jelas memperlihatkan bahawa kelapa sawit yang tidak dibaja dengan nitrogen dan fosforus dalam jangka masa yang lama akan terencat teruk dari segi tumbesaran dan pengeluaran buah.

Memandangkan tahap kalium di dalam kelapa sawit yang tidak produktif setelah tidak dibaja bersamaan dengan tahap kelapa sawit yang selalu menerima pembajaan dan mengeluarkan hasil yang baik, jelas menunjukkan bahawa pengeluaran buah tidak bergantung sepenuhnya kepada pemberian kalium. Kalium hanya diperlukan pada kuantiti yang minimum untuk fungsi asas biokimia kelapa sawit. Kedapatan nitrogen dan fosforus yang mencukupi dirasakan lebih penting untuk pengeluaran buah dengan kalium hanya cukup untuk proses-proses fisiologi utama. Fungsi biofizika kalium untuk mempertahankan tekanan 'turgor' di dalam sel-sel didapati telah dibantu oleh kation-kation lain memandangkan kation seperti magnesium dan kalsium telah diambil pada tahap yang lebih tinggi oleh kelapa sawit yang ditanam di tanah dataran pantai. Pengambilan kation ini adalah bergantung kepada kedapatan kation-kation ini di dalan tanah. Dalam keadaan di mana satu kation diambil lebih, pengambilan kation lain akan menurun dan sebaliknya. Dengan itu, jumlah kation bes di dalam kelapa sawit akan sentiasa terpelihara ditahap yang sama tidak kira kation yang mana diambil lebih. Fenomena ini dipanggil 'complementary cationic relationship' untuk tujuan menentukan tahap kation yang seimbang di dalam sistem kelapa sawit.

Hasil kajian ini dengan jelas menunjukkan bahawa keperluan kalium kelapa sawit yang ditanam di tanah-tanah lanar laut boleh dipenuhi oleh kalium yang terdapat di dalam tanah dan pemberian baja kalium tidak mendatangkan kesan positif terhadap pengeluaran buah. Pengambilan kalium dari tanah sudah cukup untuk menampung keperluan kelium bagi fungsi biokimia dan sebahagian dari fungsi biofizika pokok sawit dan dengan itu pembajaan kalium tambahan tidak diperlukan untuk tumbesaran pokok dan pengeluaran buah.

CHAPTER I

INTRODUCTION

The Oil Palm

The oil palm, *Elaeis guineensis* Jacq. is grown commercially in South East Asia, Africa, Equatorial America and the South Pacific. *E. guineensis* is a native of Africa based on the descriptions by early botanists and on the finding of fossil pollen very similar to oil palm pollen in Nigeria (Zeven, 1965). *E. guineensis* occurs naturally throughout the tropical rainforest belt of West Africa and it was observed that the natural habitat of the species is in swamps and along river banks which are too wet for the dicotyledonous trees of the rainforest (Zeven. 1967).

The first introduction into South East Asia was made in 1848 when oil palm was planted in the Bogor Botanical Garden, Indonesia. Oil palm was planted on estate basis in 1911 in Tanah Itam Ulu, Deli, North Sumatra. It was introduced to Malaysia in 1911 and 1912 where some materials of Deli origin from Sumatra were planted in Rantau Panjang, Selangor. These palms were in full bearing in 1917 and seedlings from these plantings were planted on a slightly bigger scale in Tennamaran Estate, Selangor around the same year. The oil palm planting started