



UNIVERSITI PUTRA MALAYSIA

**QUANTIFICATION OF BRIS SOIL VARIABILITY AND RESPONSE OF
KENAF (*Hibiscus cannabinus* L.) TO VARIOUS DEPTHS AND TYPES OF
SPODIC HORIZON**

KHALIL AHMED

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TYPES OF SPODIC HORIZON**

By

KHALIL AHMED

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DEDICATION



TO

MY FATHER

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

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OF KENAF (*Hibiscus cannabinus* L.) TO VARIOUS DEPTHS AND
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By

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December 2011

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Faculty: Agriculture

BRIS soils are inherently variable with various depths and types of spodic horizons. However, limited research has been conducted in characterizing and managing the BRIS soil for kenaf production in Malaysia. The objectives of the study were, to quantify the spatial variability of BRIS soil and to identify the yield limiting factors of kenaf for delineating the management zone strategy. The effect of different depths and types of spodic horizons was also determined on growth, yield and root morphology of kenaf. The study consists of two field experiments and one glass house experiment. For the first field study, geo-referenced soil samples at two depths (0-15 and 15-30 cm) and plant samples of kenaf were collected. Geostatistical techniques were applied to characterize the spatial variability of the studied area

to delineate the management zones. In the second field study effect of different depths of spodic horizon was investigated on growth, root morphology and yield of kenaf. Four locations with different depths of spodic horizons L1=20, L2=48, L3=77 and L4=118 cm were selected and morphological characteristics of soil were determined. Locations one and two are classified as Rhu Tapai series whereas; locations 3 and 4 belong to Rudua and Jambu series. A glass house study was conducted to observe the response of kenaf (growth, root morphology and yield of kenaf) to different types of spodic horizons. For this purpose, four types of undisturbed spodic horizons with the strengths S1=3.88, S2=5.03, S3=5.82, S4=8.05 and a control 0.14 kg cm⁻² (without spodic) were collected in PVC columns. Water filled pore space, air filled pore space and total pore space were determined in different types of spodic horizons. Roots of kenaf were sampled at 10, 20 and 30 cm depths from each type of spodic horizons with a metal box sized 0.01-0.01m² for morphological studies.

The results of geostatistical analysis showed moderate spatial dependence for TC, TN, P, Ca, Mg, CEC and yield of kenaf indicating that the extrinsic factor such as levelling of ridges and management practices for more than three decades restructured the variability of BRIS soil properties. At surface soil pH, TN and Mg were quantified into two management zones, while at sub-surface they were quantified into one management zone. TC and CEC were quantified into one management zone while P and Ca were quantified into two

management zones at both the depths. The yield of kenaf was also quantified into two management zones. The negative correlation of TC, TN and Ca with sand content indicating the low fertility level of BRIS soil. It was also observed that the soil properties like bulk density, sand, silt, porosity, pH, P, K, Ca and Mg did not show the significant correlation with the yield of kenaf.

Morphological features of four soils studied showed differences in the depth and thickness of horizons. The thickness of albic horizon at Rhu Tapai series was 10 and 38 cm while 67 and 102 cm were observed in Rudua and Jambu soil series. Texture of all the BRIS soil horizons was sandy in nature. Porosity percentage, P, K, Ca and Mg were observed higher in spodic horizons than top infertile horizons. Average soil surface temperature was in the order of Rhu Tapai < Rudua < Jambu series. The depth of spodic horizon had a significant effect on plant height, number of nodes, leaf area, diameter and dry matter yield of kenaf as the negative linear relationship. Stalk yield of kenaf declined by 13.60, 20.52 and 37 % at 48, 77 and 118 cm depth of spodic horizon in the soil profile. Visually, the growth in the roots of kenaf was stunted with the increase in depth of spodic horizon.

Different types of spodic horizons had a significant effect on growth, yield and root morphology of kenaf. Spodic type four was significantly higher in water filled pore space and lower in air filled pore space as compared to S1, S2, S3 and control. At 60 days of kenaf growth plant

height, leaf area, dry weight of stem and bark were significantly higher in S4 than S1, S2, S3 and control. The spodic types were significantly affected the root morphology of kenaf and the deformation of main root occurred at the strength of 8.05 kg cm⁻² in spodic type S4.

It is concluded that the mixing of spodic horizon with top infertile horizons create moderate spatial variability in the properties of BRIS soil, which affects the yield of kenaf where application of site specific management zone strategy is required. The depth and types of spodic horizons had significant effect on growth, root morphology and yield of kenaf and need to be considered in the planting of kenaf on BRIS soil.

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

**KUANTIFIKASI KEBOLEHUBAHAN TANAH BRIS DAN
TINDAKBALAS KENAF (*Hibiscus cannabinus* L.) TERHADAP
PEBBAGAI KEDALAMAN DAN JENIS HORIZON SPODIK**

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Tanah BRIS sememangnya berubah-ubah mengikut kedalaman dan jenis horizon spodik. Namun, kajian yang telah dijalankan adalah terhad dari aspek pencirian dan pengurusan tanah BRIS untuk penanaman kenaf di Malaysia. Objektif kajian ini, adalah untuk mengkuantifikasikan kebolehubahan variasi ruang tanah BRIS dan mengenalpasti faktor-faktor penghad hasil kenaf bagi strategi pengurusan zon. Kesan kedalaman dan jenis horizon spodic juga ditentukan terhadap tumbesaran, hasil dan morfologi akar kenaf. Kajian ini meliputi dua eksperimen iapangan dan satu di rumah

kaca. Bagi eksperimen pertama dilapangan, sampel tanah pada dua kedalaman (0-15 dan 15-30 cm) dan sampel tumbuhan kenaf berpandu rujukan geografi. Teknik geostatistik telah digunakan untuk mencirikan variasi ruang kawasan yang dikaji untuk menghasilkan zon pengurusan. Dalam eksperimen kedua diladang kesan kedalaman horizon spodik telah disiasat untuk tumbesaran, morfologi akar dan hasil kenaf. Empat lokasi dengan kedalaman yang berlainan spodik $L1 = 20$, $L2 = 48$, $L3 = 77$ dan $L4 = 118$ cm dipilih dan ciri-ciri morfologi tanah telah ditentukan. Lokasi satu dan dua dikelaskan sebagai siri Rhu Tapai manakala lokasi 3 dan 4 tergolong ke siri Rudua dan Jambu. Eksperimen ketiga di rumahkaca telah dijalankan untuk memerhatikan tindakbalas kenaf (tumbesaran, akar morfologi dan hasil kenaf) terhadap jenis spodic horizon. Untuk tujuan ini, empat jenis horizon spodik tidak terganggu dengan kekuatan $S1 = 3,88$, $S2 = 5,03$, $S3 = 5,82$, $S4 = 8,05$ dan kawalan $0,14 \text{ kg cm}^{-2}$ (tenpa horizon spodic) dikumpulkan ke dalam ruangan PVC. Air memenuhi ruang rongga, udara memenuhi ruang rongga dan jumlah ruang rongga telah ditentukan. Akar kenaf disampel pada 10, 20 dan 30 cm kedalaman dari setiap jenis horizon spodik dengan kotak logam bersaiz $0,01- 0,01\text{m}^2$ untuk kajian morfologi akar.

Keputusan analisis geostatistik menunjukkan pergantungan ruang sederhana untuk TC, TN, P, Ca, Mg, CEC dan hasil kenaf yang menunjukkan bahawa faktor luaran seperti meratakan rabung dan

amalan pengurusan lebih selama tiga dekad telah mengubah semula ciri dan variasi ruang tanah BRIS. Pada permukaan pH, tanah TN dan Mg mengujudkan dua zon pengurusan, manakala lapisan di bawah-permukaan menghasilkan menjadi satu pengurusan zon. TC dan KPK menghasilkan satu pengurusan zon manakala P dan Ca menghasilkan dua zon pengurusan di kedua-dua kedalaman. Hasil kenaf juga menghasil dua zon pengurusan. Korelasi negatif TC, TN dan Ca dengan kandungan pasir menunjukkan tahap kesuburan yang rendah tanah BRIS. BRIS Sifat-sifat tanah seperti ketumpatan pukal, pasir, kelodak, keliangan, pH, P, K, Ca dan Mg tidak menunjukkan korelasi yang bereti dengan hasil kenaf.

Ciri-ciri morfologi empat tanah BRIS dikaji menunjukkan perbezaan dari segi kedalaman dan ketebalan horizon. Ketebalan horizon albik pada siri Rhu Tapai adalah 10 dan 38 cm manakala 67 dan 102 cm diperhatikan pada tanah siri Rudua dan Jambu. Tekstur semua horizon tanah BRIS adalah berpasir. Peratusan ruang rongga, P, K, Ca dan Mg diperhatikan lebih tinggi pada horizon spodik daripada bahagian yang tidak subur. Purata suhu permukaan tanah adalah dalam turutan Rhu Tapai < Rudua < Jambu. Kedalaman horizon spodik mempunyai kesan yang bereti ke atas ketinggian kenaf, bilangan nod, luas daun, garispusat dan hasil bahan kering kenaf secara songsang. Hasil batang kenaf menurun sebanyak 13,60, 20,52 dan 37 % pada kedalaman 48, 77 dan 118 cm horizon spodik dalam profil tanah. Permatahatian secara kasar mendapati,

pertumbuhan akar kenaf terbantu dengan penambahan kedalaman horizon spodik.

Jenis horizon spodik telah memberi kesan yang berarti, terhadap tumbesaran, hasil dan morfologi akar kenaf. Jenis spodik S4 adalah lebih tinggi bagi air memenuhi ruang rongga dan lebih rendah bagi memenuhi ruang rongga berbanding S1, S2, S3, dan kawalan. Pada 60 hari pertumbuhan kenaf ketinggian pokok, luas daun, berat kering batang dan kulit pokok adalah lebih tinggi pada S4 berbanding S1, S2, S3 dan kawalan. Kekuatan horizon spodik menunjukkan kesan yang berarti ke atas morfologi akar kenaf belajar di kedalaman pelbagai jenis spodik. Ubah bentuk akar utama yang berlaku pada kekuatan $8,05 \text{ kg cm}^{-2}$ pada S4.

Kesimpulannya, bahawa kajian ini mendapati mencampurkan horizon spodik dengan tanah permukaan yang tidak subur menghasilkan variasi ruang sederhana untuk sifat-sifat tanah BRIS yang kesan ke atas hasil kenaf di mana memerlukan pengurusan mengikut zon, pengurusan. Kedalaman dan jenis horizon spodik telah mempengaruhi tumbesaran morfologi akar dan hasil kenaf, dan pada diberi perhatian untuk tanaman kenaf pada tanah BRIS.

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I certify that a Thesis Examination Committee has met on 15 December 2011 to conduct the final examination of Khalil Ahmed on his Doctor of Philosophy thesis entitled “Quantification of BRIS soil variability and response of kenaf (*Hibiscus cannabinus* L.) to various depths and types of spodic horizon” in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15th March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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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 institution.

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Date: 15 December 2011



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