UNIVERSITI PUTRA MALAYSIA

SOIL QUALITY AND SPATIAL VARIABILITY OF PHYSICOCHEMICAL PROPERTIES OF A FRUIT GROWING AREA IN KLUANG, MALAYSIA

MOE SHWE SIN

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By

MOE SHWE SIN

Thesis submitted to the School of Graduate Studies, Universit Putra Malaysia, in Fulfillment of the Requirements for the Degree of Master of Science.

May 2011

DEDICATION

This thesis is specially dedicated to:

My beloved parents,

U KYAW SEIN

and

DAW YI YI

My brothers and sister,

MOE THUZAR
KYAW LWIN OO
MIN SAN TUN
&
CHIN HOW BOON

Who always supported and encourage me to do the best.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the Degree of Master of Science

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May 2011

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Soil quality is a composite picture of the condition of soil for specific function. The general objective of the study is to assess soil quality status of each study area and spatial distribution of major soil nutrients in fruit growing areas to provide the information for effective nutrient application. In this study, the systematic method for rating soil quality proposed by Karlen and Stott (1994) was used to evaluate the soil quality indices of a fruit growing area located in the Modern Agriculture Farm, Kluang (2.00564477° N and 103.19889165° E with elevation 30.4 m above sea level). The four study

sites include a banana area, a jackfruit area, a lime area and a fallow or uncultivated area with a total of about 16.3 ha.

The soil samples for soil physico-chemical analyses were taken using a stainless steel auger at a depth of 0-20 cm, 20-40 cm and 40-60 cm, respectively. For microbial biomass carbon and nitrogen analyses, soil samples were also taken at a depth of 0-10cm for all the areas. Soil physico-chemical properties determined were soil pH, total nitrogen (TN), organic carbon (OC), available phosphorus (AP), cation exchange capacity (CEC) and exchangeable potassium (K), exchangeable calcium (Ca) and exchangeable magnesium (Mg). Latitude and longitude of the study area at each sampling point was taken using a hand held GPS (Trimble Geo XH). At each sampling point, three bulk samples were taken and mixed to get a composite sample. Microbial biomass C and N analyses were carried out using chloroform fumigation extraction method.

The descriptive statistics and correlation study were analyzed using SAS 9.2 statistics software and Sigma Plot 11.0 software. Geostatistical analysis was carried out using Gamma design software (GS+ version 5.0) and spatial maps of the study area and major nutrients were registered into Map Info Professional software for GIS manipulation. Significant differences were

found in some soil properties. The chemical soil properties of the top soils (pH, OC and CEC) were significantly different between fruit growing areas with uncultivated area. The values of soil nutrients (TN, available P, exchangeable K, Ca and Mg) in three fruit growing areas also showed significant differences with uncultivated area. However, in the case of bulk density and porosity, there is no significant difference between three fruit areas with uncultivated area ($p = 0.05$).

The correlation between the soil chemical properties at top soils in banana area showed negative correlation between pH and OC ($r = 0.335$, $n=60$), while positive correlations were found between pH and AP ($r = 0.358$, $n=60$), between CEC and OC ($r = 0.432$, $n=60$) and between Ca and Mg ($r = 0.449$, $n=60$), respectively. In the jackfruit area, significant positive correlations were obtained between TN and CEC ($r = 0.45$, $n=30$), and between TN and AP ($r = 0.352$, $n=30$) while negative correlation was found between OC and Ca ($r = 0.418$, $n=30$). In the lime area, the significant positive correlations were found between pH and TN ($r = 0.356$, $n=30$), OC and TN ($r = 0.46$), and Ca and AP ($r = 0.376$, $n=30$), respectively.

The status of soil nutrients of the three fruit growing areas were compared with other Malaysian soils. In banana and jackfruit areas, N, P and K status

were low in comparison with other Malaysian soils, whereas in lime area, it is low in N and P and moderate in K status. The application of N, P and K fertilizers should be applied in all fruit growing areas because of the low status of these soil nutrients.

Geostatistical analysis of soil pH and soil nutrients of the three fruit growing and an uncultivated area was also carried out. The best fitted semivariogram models of pH, TN, AP and EK were spherical, linear, linear and exponential, respectively, in the banana area; linear, spherical, spherical and linear, respectively, in the jackfruit area; linear, exponential, linear and exponential, respectively, in the lime area, and spherical, linear, exponential and linear, in the uncultivated area. The strong spatial dependency was only found for pH in the banana area. Moderate spatial dependencies were found for EK in banana area, for TN and AP in jackfruit area, for TN and EK in lime area and pH and AP in uncultivated area. Moreover, weak spatial dependencies were found for TN and AP in banana area, for pH and EK in jackfruit area, for pH and AP in lime area and TN and EK in uncultivated area, respectively. The spatial distributions of these soil properties at each area were shown in variation map of each soil properties, and the required amount of fertilizer needed to supply each nutrient for successful cultivation an be calculated based on the ranges of nutrients distributed in each fruit growing area.

The evaluation of soil quality indices for the three fruit growing areas (banana, jackfruit and lime) and an uncultivated area showed different soil quality index score for each area. The soil quality index scores for the four areas are as follows: jackfruit > lime > banana > fallow. The score of soil quality for each area was calculated by integrating the essential soil functions such as accommodating water entry, facilitating water movement and availability, resistance to surface structure degradation, and sustainability of fruit quality and productivity. The scores of each soil function were also different with each study area and this can be seen through the effect of different cultural practices on soil function. For the function of accommodating water entry, the function scores showed the order: jackfruit (0.18) > banana (0.17) > lime (0.16) > fallow (0.13). For the function score of facilitating water movement and availability, the order was jackfruit (0.15) > banana (0.14) > lime (0.13) > uncultivated (0.12). However, for the function score of surface structure resistance and degradation, the results showed the order of: jackfruit and uncultivated (0.16) > lime (0.15) > banana (0.13). The function score of sustainability of fruit quality and productivity, the result showed the order: lime (0.83) > jackfruit (0.41) > banana (0.33) > uncultivated (0.32). The grand total soil quality scores of the four study areas are jackfruit area=0.90; lime area=0.89; banana area=0.77; fallow=0.69. This showed that the study areas are in good condition both as a successful fruit production

and also for sustainable environment. The information of soil quality for each study plot with different cultural practices is useful for the sustainable production of fruit, and also as an indicator for environmental degradation.

The presence of microbial communities in soil is also considered an important indicator of soil quality and the position they are found mostly in the top soil regardless of their availability and management practices are also highly dependent on soil nutrient status. Quality information for each plot of land with the study of different cultural practices is useful for continuous production of fruit and caring environmental impact of decomposition.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan penanugerahan Master sains

KUALITI TANAH DAN KEPELBAGAIAN RUANG SIFAT FIZIKO-KIMIA DI KAWASAN BUAH-BUAHAN, KLUANG, MALAYSIA

Oleh

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May 2011

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Kualiti tanah memberi gabungan gambaran keadaan sesuatu tanah untuk berfungsi secara khusus. Objektif umum kajian adalah untuk menilai status kualiti tanah bagi setiap kawasan kajian dan untuk mengetahui taburan nutrien tanah utama di kawasan buah-buahan yang semakin meningkat bagi memberi maklumat tentang nutrien-nutrien berkesan yang boleh digunakan oleh pertani. Dalam kajian ini, kaedah sistematik untuk menilai kualiti tanah yang telah dicadangkan oleh Karlen dan Stott (1994) digunakan bagi menilai indeks kualiti sesuatiu kawasan penanaman buah-buahan yang terletak di kawasan pertanian moden, Kluang (2,00564477° N dan 103.19889165 ° E)

dengan ketinggian 30.4m di atas paras laut. Kajian dijalankan di empat kawasan iaitu kawasan pisang, kawasan nangka, kawasan limau nipis dan kawasan yang terbiar dengan jumlah sekitar 16.3 ha.

Sampel tanah untuk analisis fiziko-kimia tanah diambil dengan menggunakan auger keluli tahan karat, pada kedalaman 0-20 , 20-40 dan 40-60 cm. Untuk analisis Karbon dan N biojisim microb, sampel tanah diambil di kedalaman 0-10 cm. Latitud dan longitud kawasan kajian pada setiap titik pensampelan diambil menggunakan GPS (Trimble Geo XH). Pada setiap titik pensampelan, tiga sampel pukal diambil dan dicampur untuk mendapatkan sampel komposit. Sifat fiziko-kimia tanah seperti tekstur, ketumpatan pukal dan zarah, pH tanah, jumlah nitrogen (TN), karbon organik (OC), fosforus tersedia (AP), keupayaan pertukaran kation (KPK) dan kalium tukarganti (K), kalsium tukarganti (Ca) dan magnesium tukarganti (Mg) dianalisis di makmal. Analisis karbon dan N biojisim mikrob dilakukan dengan menggunakan kaedah pengasapan ekstraksi kloroform. Statistik deskriptif dan kajian korelasi dianalisis dengan menggunakan perisian statistik SAS 9.2 dan perisian Sigma Plot 11.0. Analisis Geostatistik dilakukan dengan mengguna perisian rekabentuk Gamma (GS + versi 5.0) dan peta ruangan kawasan kajian dan nutrien utama telah dimasukan ke dalam perisian Map Info Professional untuk manipulasi GIS.

Perbezaan signifikan telah ditemui untuk beberapa sifat tanah. Sifat kimia tanah pada tanah atas (pH, OC dan KPK) nyata berbeza antara kawasan penanaman buah dengan kawasan yang terbiar. Status nutrisi tanah (TN, P tersedia, bes tukarganti K, Ca dan Mg) bagi ketiga-tiga kawasan penanaman buah menunjukkan perbezaan yang signifikan dengan kawasan yang terbiar. Walau bagaimanapun, ketumpatan pukal dan ruang rongga tidak ada perbezaan signifikan antara ketiga-tiga kawasan buah-buahan dengan kawasan yang terbiar ($p = 0.05$)

Korelasi antara sifat kimia tanah bagi tanah atas di kawasan pisang menunjukkan korelasi negatif ditemui antara pH dan OC ($r= 0.335$, $n=60$), sedangkan korelasi positif ditemui antara pH dan P tersedia ($r = 0.358$, $n=60$), antara KPK dan OC ($r = 0.432$, $n=60$) dan antara Ca dan Mg ($r = 0.449$, $n=60$). Di kawasan nangka, korelasi positif dan signifikan ditemui antara TN dan KPK ($r = 0.45$, $n=30$), dan antara TN dan P tersedia ($r = 0.352$, $n=30$) , manakala korelasi negatif yang signifikan ditemui antara OC dan Ca ($r = 0.418$, $n=30$). Di kawasan limau nipis, korelasi positif yang signifikan ditemui antara pH dan TN ($r = 0.356$, $n=30$), OC dan TN ($r = 0.46$, $n=30$) dan Ca dan P tersedia ($r = 0.376$, $n=30$).

Status nutrien tanah pada ketiga-tiga kawasan penanaman buah-buahan telah dibandingkan dengan tanah-tanah lain di Malaysia. Di kawasan pisang dan nangka, status N, P dan K adalah rendah berbanding tanah-tanah lain di Malaysia sedangkan di kawasan limau nipis adalah rendah dengan N dan P dan sederhana dalam status K. Aplikasi baja N, P dan K harus diamalkan dalam kesemua kawasan penanaman buah kerana status nutrien tersebut adalah rendah dalam tanah.

Analisis geostatistik bagi pH tanah dan nutrien tanah di ketiga kawasan penanaman buah dan kawasan yang terbiar telah dijalankan. Model semivariogram yang paling sesuai bagi pH, TN, P tersedia dan tukarganti K adalah bentuk sfera, lurus, lurus dan eksponen, masing-masing bagi kawasan pisang; lurus, sfera, sfera dan lurus, masing-masing di kawasan nangka; lurus, eksponen, lurus dan eksponen, masing-masing di kawasan limau nipis dan sfera, lurus, eksponen dan lurus, masing-masing di kawasan yang terbiar. Pergantungan ruang yang kuat hanya dijumpai bagi pH dalam kawasan pisang. Pergantungan ruang sederhana ditemui bagi tukarganti K dalam kawasan pisang, bagi TN dan P tersedia dalam kawasan nangka, bagi TN dan tukarganti K dalam kawasan limau nipis dan pH dan P tersedia dalam kawasan yang terbiar. Selain itu, pergantungan ruang yang lemah dijumpai bagi TN dan P tersedia di kawasan pisang, untuk pH dan

tukarganti K di kawasan nangka, untuk pH dan P tersedia di kawasan limau nipis dan TN dan tukarganti K di kawasan terbiar. Edaran ruang bagi setiap sifat-sifat tanah di setiap kawasan ditunjukkan dalam peta variasi. Jumlah baja yang diperlukan untuk membekalkan setiap nutrien bagi penanaman yang berjaya boleh dikira berdasarkan kadar nutrien yang diedarkan dalam setiap kawasan penanaman buah.

Penilaian indeks kualiti tanah bagi ketiga-tiga kawasan penanaman buah (pisang, nangka dan limau napis) dan kawasan yang terbiar menunjukkan perbezaan indeks kualiti tanah bagi setiap kawasan. Skor kualiti tanah untuk keempat kawasan adalah seperti berikut: nangka > limau nipis > pisang > kawasan terbiar. Skor kualiti tanah untuk setiap kawasan dikira dengan mengintegrasikan fungsi tanah penting seperti infiltrasi air, pergerakan air dan ketersediaan, struktur permukaan dan degradasi dan kelestarian kualiti dan pengeluaran buah-buahan. Skor bagi setiap fungsi tanah juga berbeza bagi setiap kawasan kajian dan ini dapat dilihat bahawa sistem pengurusan yang berbeza mempunyai kesan pada fungsi tanah.

Untuk fungsi infiltrasi air skor yang diperolehi adalah seperti berikut: nangka (0.18) > pisang (0.17) > limau nipis (0.16) > kawasan terbiar (0.13). Bagi fungsi pergerakan air dan ketersediaan pula, skor yang diperolehi adalah seperti berikut: nangka (0.15) > pisang (0.14) > limau nipis (0.13) >

kawasan terbiar (0.12). Fungsi penahanan penguraian permukaan struktur skor yang diperolehi adalah seperti berikut: nangka dan kawasan terbiar (0.16) > limau nipis (0.15) > pisang (0.13). Untuk fungsi bagi mempertahankan kualiti dan produktiviti buah-buahan skor yang diperolehi adalah seperti berikut: limau nipis (0.83) > nangka (0.41) > pisang (0.33) > kawasan terbiar (0.32). Jumlah keseluruhan skor kualiti tanah diempat kawasan adalah seperti berikut: nangka = 0.90, limau nipis = 0.89, pisang = 0.77 dan kawasan terbiar = 0.69. Kajian ini menunjukan keadaan yang baik untuk pengeluaran buah-buahan dan keseimbangan alam sekitar. Maklumat bagi kualiti tanah untuk setiap plot kajian dengan amalan budaya yang berbeza adalah berguna pengeluaran buah-buahan yang berterusan serta mengambil berat kesan penguraian alam sekitar.

Kehadiran komuniti mikrob dalam tanah juga dianggap sebagai penunjuk kualiti tanah yang penting dan kedudukan mereka ditemui sebahagian besarnya di tanah atas tanpa mengambilkira amalan pengurusan dan ketersediaan mereka juga sangat bergantung pada status nutrien tanah. Maklumat kualiti tanah untuk setiap plot kajian dengan amalan budaya yang berbeza adalah berguna untuk pengeluaran buah yang berterusan serta mengambil berat kesan penguraian alam sekitar.

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I certify that a Thesis Examination Committee has met on 4th May 2011 to conduct the final Examination of MOE SHW SIN on her thesis entitled "Soil Quality And Spatial Variability Of Physico-chemical Properties Of A Major Fruit Growing Area In Kluang, Johore, Malaysia" 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 Master of Science in Land Resource Management degree.

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DECLARATION

I declare 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.

MOE SHWE SIN

Date: 4 th May 2011

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