UNIVERSITI PUTRA MALAYSIA

MINERALOGICAL AND CHEMICAL PROPERTIES OF SOME ACID SULFATE SOILS IN MALAYSIA AND THEIR EFFECTS ON THE GROWTH PERFORMANCE OF OIL PALM SEEDLINGS (ELAEIS RUINEENSIS, JACQ)

EDGARDO ANTIGA AUXTERO

FP 1990 1

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by

Edgardo Antiga Auxtero

Thesis Submitted in Fulfilment of the Requirements
for the Degree of Doctor of Philosophy
in the Faculty of Agriculture,
Universiti Pertanian Malaysia,
Serdang, Selangor

September 1990

With great appreciation to: My Mother,

Auntie Regina and

Late Grandfather

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ACKNOWLEDGEMENTS

The author would like to express his profound gratitude to the following people from various spheres of endeavour for their invaluable contribution in the completion of this dissertation:

The Malaysian Government under the auspices of the Training and Career Development, Public Services Department, Malaysian Technical Cooperation Programme (MTCP) for awarding this doctoral scholarship; Messrs. Wan Yusof Abdullah and Mahasan Mustapa; Mrs. Mariani binte Antung and to the MTCP staff, Public Services Department at Kuala Lumpur, for their help in processing my scholarship document;

Mrs. Virginia H. Benavidez, Consul General and First Secretary, The Embassy of the Republic of the Philippines at Kuala Lumpur, for recommending me to the MTCP and to the Executive Officer, Special Committee on Scholarship of the National Economic Development Authority (NEDA) Philippines, for facilitating the approval of my study overseas;

Dr. Rodolfo C. Nayga, former President, Central Mindanao University, for nominating me to this scholarship and Dr. Leonardo A. Chua, President, Central Mindanao University, for granting my study leave;

Dr. Shamshuddin Jusop, my Major Supervisor and Dr. S. Paramananthan, my Co-Supervisor, for their invaluable comments and guidance in the conduct of this thesis;

Mr. Chan Yik Yuan, Deputy Director, Kuala Lumpur Department of Agriculture; Messrs. Syed Fadzil bin Shahabudin and Perumal of Shah Alam Department of Agriculture, for their tremendous help in the soil profile description and soil-correlation studies;

Mr. Zainal Kharib, Head of Department of Agriculture, Kelang and Mrs. Nor Rafidah binte Dan, District Engineer of Kelang Irrigation and Drainage Department, for providing technical assistance during the course of my fieldwork;

Mr. Zulkifli bin Abdul Wahab, Head of Pulau Lumut Agriculture Centre and his family; Messrs. Salekon bin Takim and Wan, for their hospitality during my stay at Pulau Lumut and their personal assistance during the course of my data collection and fieldwork;

Pusat Penyelidikan Atom Tun Ismail (PUSPATI), for allowing the use of SEM-EDXRA equipment;

Mrs. Aminah Jusoh and Mr. Ho Ooi of the Faculty of Veterinary Medicine and Animal Science, UPM for their assistance in scanning and transmission electron microscope identification of soil minerals;

Messrs. Roslan bin Abdul Ghani, Draftsman of Soil Science Department, Universiti Pertanian Malaysia, Zainal bin Rajuddin of Malaysian Agricultural Research and Development Institute (MARDI) and Staff of Cartography Section, Kuala Lumpur Department of Agriculture, for providing their expertise in cartography and graphics;

Haji Ahmad Wahab, Head of Chemical Analysis Unit of (MARDI), for allowing the use of autoanalyzer and Inductively Coupled Plasma Emission Atomic Spectrophotometer (ICPEAS) and to Messrs. Malek bin Yaacob and Abdul Karim Latiff; Ms. Rosnah binte Jasin, who assisted in my laboratory works;

Dr. Zainap binte Hamzah, Head of Plant Testing Unit. Rubber Research Institute of Malaysia (RRIM), for allowing the use of atomic absorption spectrophotometer and Mr. Liew Khei Yip of RRIM for his assistance in total aluminium determination;

Mr. Poon Yew Chin of Harrisons and Crosfield Malaysia Plantation Berhad (HMPB) at Banting, Selangor, for providing the oil palm seedlings for greenhouse experiment and for his professional assistance during the course of my data collection;

Mr. Azali bin Mhd Sab soil laboratory assistant of Universiti Pertanian Malaysia (UPM), for his assistance in soil mechanical analysis and mineralogy studies;

Mr. Anuar Abdul Rahim of Soil Science Department, UPM and Dr. Noel Grundon of Queensland University, for their guidance in computer programming and statistical interpretation of the data;

Messrs. Philip Kapia, Juperik Apau, Irwin Fernandez, Susin Ambud, Martin Cusong and Judas; Mz. Lilian Perez, Connie Comilus, Vera Comilus and Ramas Panting who assisted in my glasshouse experiment at UPM;

Members of the Auxtero family, my friends who composed the Filipino Community in Serdang and in Kajang, Malaysia, especially The Manalo's, The Madrigal's, The Almeida's family and Mrs. Marina Baptist for their continued encouragement and moral support for the completion of my study;

To all, who in one way or another, have contributed directly or indirectly to the success of this dissertation;

Thanks and praise be to the God Almighty for His blessings and for keeping me fit throughout the duration of my stay in Peninsular Malaysia.

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LIST OF ABBREVIATIONS

DID	: Drainage Irrigation Department
dS/m	: deciSiemens per meter
FAO	: Food and Agriculture Organization
HMPB	: Harrisons Malaysia Plantation Berhad
ICPEAS	: Inductively Coupled Plasma Emission Atomic Spectrophotometer
kPa	: kilo Pascal
MARDI	: Malaysian Agricultural Research and Development Institute
PUSPATI	: Pusat Penyelidikan Atom Tun Ismail
RRIM	: Rubber Research Institute of Malaysia
SEM	: Scanning Electron Microscope
SEM-EDXRA	: Scanning Electron Microscope-Energy Dispersive X-Ray
TEM	: Transmission Electron Microscope
UPM	: Universiti Pertanian Malaysia
XRD	: X-ray Diffraction Analysis

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

MINERALOGICAL AND CHEMICAL PROPERTIES OF SOME ACID SULFATE SOILS IN MALAYSIA AND THEIR EFFECTS ON THE GROWTH PERFORMANCE OF OIL PALM SEEDLINGS (Elaeis guineensis, Jacq)

by

Edgardo Antiga Auxtero

September 1990

Major Supervisor: Dr. Shamshuddin Jusop

Faculty : Agriculture

Acid sulfate soils are characterized by a very low pH and a high aluminium concentration resulting from the chemical and biological oxidation of pyrite upon drainage. These soils have low agricultural potential due to high acidity and poor physical conditions, which adversely affect crop growth. Successful reclamation and management of acid sulfate soils would require an in-depth understanding of the soil's chemical and mineralogical properties.

In this study, acid sulfate soils at Pulau Lumut, Kelang were mapped, characterized morphologically and chemically, and classified. Soil solutions were extracted on samples from soil

pit, limed and oxidized soils and a pot experiment at the matrix suction of 10 kPa and the activities of the major cations and anions were calculated by Geochem. XRD and TGA were carried out to determine the mineralogy of the various soil horizons. The morphological features of the minerals in the soils were studied by TEM and SEM. A controlled pot experiment was conducted to assess the performance of oil palm seedlings grown on acid sulfate soils under freely drained and waterlogged conditions.

Drainage resulted in the development of true acid sulfate soils. Sulfic Tropaquepts (Tongkang and Jawa series) and Sulfaquepts (Sedu and Parit Botak series) occur in the bunded area drained 25 years ago. A juvenile Sedu silty type (Sulfaquepts) also occur in the area drained about 8 years ago. SEM study showed that these soils originated from marine alluvial deposits as confirmed by the presence of marine biorelicts.

Results of XRD analysis showed that kaolinite, smectite, mica and mica-mixed layers were the dominant minerals in the clay fraction of all soils. Gibbsite, polygonally-shaped and tubular forms of halloysite were also found. Jarosite crystals of about 1 μm believed to be formed from precipitation in soil solutions were found in the soils. Activities of K^+, Fe^{3+} and SO_4^{2-} in the soil solution were found to be supersaturated with respect to jarosite. High activities of Al^{3+} and SO_4^{2-} in the

soil solution resulted in the precipitation of alunite, basalunite and jurbanite. Application of lime at 5 t/ha increased the pH of the Ap horizon from about 3.5 to 5.0. This reduced the activities of aluminium, iron and manganese to a minimal level.

Over 90% of the aluminium in the soil solution was in the inorganic monomeric form, with Al^{3+} and $Al(SO_4)^+$ as the major aluminium species. These aluminium species reduced the relative tap root length of oil palm seedlings. Al^{3+} and $Al(SO_4)^+$ corresponding to 90% relative tap root length were about 100 μM and 500 μM respectively. Respective aluminium and iron concentrations in the root corresponding to a 10% reduction in the relative tap root length of oil palm seedlings were 1.3% and 0.2%.

Oil palm seedlings grown on soils with low activities of aluminium and iron exhibited good growth. This was obtained on freely drained top soils. It is advisable to flush out sulfate as much as possible, and thereafter, maintain the pyritic horizon in a flooded condition.

Abstrak tesis yang diserahkan kepada Senat Universiti Pertanian Malaysia sebagai memenuhi syarat yang diperlukan untuk mendapatkan Ijazah Doktor Falsafah.

SIFAT-SIFAT MINERALOGI DAN KIMIA BEBERAPA TANAH ASID SULFAT DI MALAYSIA DAN KESANNYA KE ATAS PERTUMBUHAN ANAK BENIH KELAPA SAWIT (Elaeis guineensis, Jacq)

Oleh

Edgardo Antiga Auxtero

September 1990

Ketua Penyelia : Dr. Shamshuddin Jusop

Fakulti : Pertanian

Tanah asid sulfat dicirikan oleh pH yang sangat rendah dan kandungan aluminium yang tinggi, hasil daripada pengoksidaan pirit melalui saliran. Tanah-tanah ini kurang berpotensi untuk pertanian kerana keasidan yang tinggi dan keadaan fisikal yang lemah, iaitu sifat-sifat yang mempengaruhi pertumbuhan tanaman. Kejayaan penubusgunaan dan pengurusan tanah asid sulfat bergantung kepada kefahaman yang mendalam tentang ciri-ciri kimia dan mineralogi tanah.

Dalam kajian ini, tanah asid sulfat di Pulau Lumut, Kelang dipeta, diciri dari segi morfologi dan kimia, dan dikelaskan.

Larutan tanah yang wujud di tahap sedutan matrik 10 kPa diekstrak daripada sampel-sampel lelubang tanah, tanah yang telah dikapur dan tanah yang teroksid. Aktiviti-aktiviti kation dan anion utama diramalkan dengan menggunakan program Geochem. Kaedah-kaedah XRD dan TGA telah digunakan untuk penentuan mineralogi di berbagai-bagai horizon tanah. Morfologi mineral tanah ditentukan dengan kaedah-kaedah SEM dan TEM. Ujian kawalan berpasu telah dijalankan untuk menentukan pertumbuhan anak benih kelapa sawit pada tanah asid sulfat di bawah keadaan tersalir dan terendam air.

Penyaliran mengakibatkan terbentuknya tanah asid sulfat jenis Sulfic Tropaquepts (siri Tongkang dan Jawa) dan Sulfaquepts (siri Sedu dan Parit Botak), yang terdapat di sekitar kawasan yang telah disalirkan selama 25 tahun. Tanah jenis Sedu berkelodak (juga Sulfaquepts) dijumpai di kawasan yang telah disalirkan lebih kurang 8 tahun yang lepas. Kajian SEM menunjukkan bahawa tanah-tanah ini terbentuk daripada penimbunan lanar laut sebagaimana ditunjukkan oleh kehadiran biorelik lautan.

Keputusan analisis XRD menunjukkan kaolinit, smectit, mika dan lapisan bercampur-mika merupakan mineral utama di dalam bahagian lempung bagi semua siri tanah. Gibsit dan haloisit yang terbentuk poligonal serta tiub juga terdapat. Kristal jarosit yang berukuran 1 um yang terdapat di dalam tanah,