UNIVERSITI PUTRA MALAYSIA

ALLEVIATION OF SOIL ACIDITY BY APPLICATION OF COMPOST FOR GRAIN MAIZE PRODUCTION

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ALLEVIATION OF SOIL ACIDITY BY APPLICATION OF COMPOST FOR GRAIN MAIZE PRODUCTION

By

E N I T A

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, In Fulfilment of the Requirement for the Degree of Master of AgricultureScience

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DEDICATION

To

my beloved husband ***Y U R I Z A L***

and my wonderful childrens *Persy Laseria Rizki*

Rahmad Tridio Syahputra

Olivia Gemala Ranty,

my mother's ***Rosmalinar,*** my father's ***Sahar Yusuf*** and my uncle ***Jurnalis Kamil and Adonis Noer*** Whose sacrifice and understanding has enabled me to complete this study successfully

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Agricultural Science

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Chairman : Prof. Dr. J. Shamshuddin

Faculty : Agriculture

Returning organic materials in the form of compost can be an alternative method of alleviating soil acidity. This is because decomposted organic materials help chelate Al, thereby reducing its toxicity to crop. A set of three experiments was conducted in a glasshouse at UPM. The first experiment was the used of inoculant and activator in composting. This experiment was to evaluate the effectiveness of different type of inoculants as decomposters. The second experiment was a pot experiment using grain maize variety PJ-58 as a test crop to determine the best compost. The soil type was the Bungor series soil (Typic Paleudult). The third experiment (also pot experiment) was to grow grain maize on the Bungor and Kuantan series soils in order to evaluate the effectiveness of compost as a soil ameliorant.

The results indicated that during composting the temperature of the compost increased up to > 60 ^{0}C. This showed that effective microorganisms (EM) is a good inoculant to decompose palm oil mill effluent. It was found that compost application had alleviated soil acidity. Applying compost at the rate of 20 t/ha plus 2 t GML/ha increased soil pH from 4.6 to 5.7. The exchangeable K, Ca and Mg had also increased. This treatment gave the best result.

For the Bungor series soil, the critical Ca concentration in the tissue was 0.65 %, while the critical Mg concentration it was 0.42 %. The critical exchangeable Ca concentration was 2.7 $cmol_c$/kg soil. The best compost was compost type 2 (CT2) where EM as an inoculant while urea and rice branch as an activator was applied. Its application to the soil gave the high exchangeable Ca and Mg, soil cation exchange capacity and the lowest exchangeable Al. It also gave the highest maize dry weight. It was noted that compost application had improved soil fertility leading to increase in grain maize yield.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia se bagai memenuhi syarat keperluan untuk mendapatkan Ijazah Master Sains Pertanian

PERBAIKAN TANAH ASID DENGAN PEMBERIAN KOMPOS UNTUK PRODUKSI TANAMAN JAGUNG BIJIRIN

Oleh

E N I T A

April 2002

Pengerusi : PROF. DR. J. SHAMSHUDDIN

Fakulti : Pertanian

Pengembalian bahan organik dalam bentuk kompos merupakan sebagai salah satu alternatif untuk pembaikan tanah asid. Disebabkan oleh pengomposan bahan organik boleh menolong mengkelat aluminium dan seterusnya akan menurunkan keracunan pada tanaman.

Suatu rangkaian eksperimen yang terdiri dari tiga langkah percubaan telah dilaksanakan di rumah kaca Universiti Putra Malaysia. Eksperimen I ialah penggunaan inokulan dan aktivator dalam proses pembuatan kompos. Eksperimen ini bertujuan untuk menguji keefektifan beberapa jenis inokulan dan aktivator dalam proses pembuatan kompos. Sementara eksperimen yang ke dua iaitu eksperimen berpasu menggunakan tanaman jagung (Zea mays L.)

variati PJ-58 sebagai tanaman ujian untuk mendapatkan jenis kompos yang terbaik, ditanam pada tanah siri Bungor (Tipik Paleudult). Selanjutnya eksperimen ke tiga menanam tanaman jagung sebagai tanaman penguji pada tanah siri Bungor dan siri Kuantan. Eksperimen ini bertujuan untuk mengetahui keberkesanan kompos sebagai bahan pembaik tanah.

Hasil percubaan ini menunjukkan bahawa selama proses pembuatan kompos suhu meningkat hingga >60 ^{o}C. Ini memperlihatkan bahawa mikroorganisma efektif (EM) ialah inoculant yang baik digunakan dalam proses pengomposan POME dan habuk gergaji kayu. Didapati bahawa penggunaan kompos telah memberikan hasil yang menguntungkan sebagai pembaik tanah asid dengan kadar 20 t/ha ditambah dengan 2 GML/ha di mana dianya dapat menaikkan pH tanah dari 4.6 ke 5.7 serta meningkatkan kandungan nutrien tanah termasuk K, Ca dan Mg bertukarganti. Pemberian kompos pada kadar 20 t/ha telah memberikan hasil yang terbaik dalam hal kualiti dan jumlah hasil yng didapati.

Pada tanah siri Bungor, tahap kritikal kepekatan kalsium di dalam tisu tanaman ialah 0.65%, sementara tahap kritikal kepekatan Mg ialah 0.42%. Tahap kritikal kepekatan kalsium tukarganti ialah 2.7 $cmol_c$/kg tanah. Kompos yang terbaik ialah jenis 2 kerana ia boleh menjadikan Ca dan Mg bertukarganti menjadi tinggi, serta aluminium bertukarganti menjadi rendah. Ianya juga membolehkan berat kering tanaman paling tinggi. Maka dalam hal ini dicatatkan bahawa penggunaan kompos dapat memperbaiki kesuburan tanah dan meningkatkan hasil tanaman jagung bijirin.

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CHAPTER I

INTRODUCTION

The world is using about 40 % of the potential land sources for agricultural purpose. The areas that have high potential for agricultural development are partly located in tropical region where the soils are acidic and have low fertility status. These highly weathered soils are taxonomically classified as Ultisols and Oxisols.

Ultisols and Oxisols are very widespread in Malaysia, constituting approximately 72 % of the total land area (IBSRAM, 1985). As a result of weathering, bases are leached. These soils are characterized by low pH, low cation exchange capacity (CEC) , high soil solution Al concentration and Ca and/or Mg deficiencies, which are limiting to crop growth. It is important to overcome these problems so that the soils can be useful for crop production.

Currently, the main agricultural crops of Malaysia are rubber, oil palm and cocoa. These plantation crops are, to a large extent, grown on Ultisols and Oxisols. These soils have occasionally been used for intercroping with corn and groundnut during immature period of rubber and oil palm replanting, but yields were reported to be low due to poor soils fertility, including Al toxicity and subsoils Ca and/or Mg deficiencies (Shamshuddin et al., 1991).

Corn is the world's third most important food crop after wheat and rice. Corn is mainly used for animal feed, human food and many unique industrials and commercial products in many parts of the world. In Malaysia, it is mainly used as animal feed. The country imports grain corn for feed amounting to millions of Ringgit. To meet the food requirement of chicken, grain maize production should be increased. Instead of looking to increased production through new cultivated areas, emphasis should be on the intensification of agriculture on the present land by the use of proper fertilizers and other inputs.

Malaysia produces a large amount of agricultural wastes. It is estimated that more than 21 million tones of palm oil mill effluents (POME) are generated annually as processing wastewater (Chan et al., 1983). About 353,000 tones sawdust are available every year (Tan, 1999). This organic matter if not properly managed may result in environmental pollution. POME is currently being utilized in agriculture as an organic fertilizer. However, direct application of such effluent is affecting the growth of oil palm seedlings. Application of undecomposed POME to sandy tailings reduced the growth of mustard greens (Radziah et al., 1997). The inhibition of plant growth has been closely associated with the presence of phenolic substance.

Lime and organic matter can be used to ameliorate acid soils. Liming material in Malaysia is ground magnesium limestone (GML). The organic matter for land application is in the form of compost, which can be made from POME and/or sawdust.

Compost will supply extra nutrients and will improve soils organic matter as well as the soils chemical and physical properties.

Haug (1980) defined composting as the biological decomposition and stabilization of organic substrates under conditions that allow development of thermophilic temperatures as a result of biologically produced heat, with a final product sufficiently stable for storage and application to land without adverse environmental effects. The conditions needed for a diverse mixture of soil life are a warm soil, adequate moisture and drainage, and a soil pH above 6. These conditions that enhance soil life usually produce maximum plant growth, although exceptions do occur

Objectives of the study

The objective of this study were:

1. To determine the suitable inoculant and activator as composter and its possibility to produce compost;
2. To evaluate different types of compost as soil ameliorant and grain maize growth; and
3. To determine the effective dosage of compost to soil acidity alleviation and grain maize production.

CHAPTER 11

LITERATURE REVIEW

Acidic Soils

Acid soils are most common where high precipitation and free drainage favor leaching and biological production of acids. Acid related factors limiting plant growth include acidity itself, Al toxicity, Mn toxicity and Ca deficiency. These tend to occur together, and they interact (Singer and Munn, 1999).

Soil becomes acidic in high rainfall areas by leaching of considerable portions of exchangeable basic cations. Although some acidic soils develop from acidic parent materials, most soils develop acidity by leaching. As water containing hydrogen cations from various weak acids (such as carbonic and organic acids) moves through the soils, some of the aluminium cations (mostly $Al(OH)_2^+$) replace the adsorbed basic exchangeable cations (Ca^{2+}, Mg^{2+}, K^+, and Na^+) ; then the leaching water carries the removed cations deep into the soil profile or into the groundwater (Miller and Donahue, 1990).

The process of aluminium replacing basic cations is known as cation exchange. The more the leaching, the more acidic the soil becomes. Developing an acidic soil requires decades and centuries. The sources of H^+ ions, which are the initial source of solution acidity are (Miller and Donahue, 1990):

1. Carbon dioxide from humus decomposition and root respiration;
2. Oxidation of NH_4^+ from fertilizers;
3. Oxidation of added elemental sulfur;
4. Excreted H^+ ions by plant roots;
5. Acid rain (sulfur and nitrogen oxide pollutants); and
6. Crop removal of the basic cations (Ca, Mg, K, Na) and excretion of H^+ by roots.

Acid Soil Infertility

Acid soils may also be generated by long term geological processes (Kamprath, 1984), reflecting the composition of the earth's surface materials. In addressing more directly the impacts of cycling of nitrogen and sulfur expressed as pH changes in soil, a description of the nature of soils and acid soils is required. Soil acidity is a major growth-limiting factor for plants in many parts of the world. Soils are acid because their parent materials are initially low in the basic cations (Ca^{2+}, Mg^{2+}, K^+, and Na^+) or because these elements have been removed from the soil profile by normal rainfall, leaching or the harvesting of crops.

Growth limiting factors that have been associated with the acid soil infertility complex include toxicities of Al^{3+}, Mn^{2+}, and other metal ions, low pH (H^+ toxicity), and deficiencies or unavailability of certain essential elements, particularly Ca, Mg, P, and Mo (Kamprath, 1984; Foy et al., 1978). The low fertility status does not allow the soil to be very productive agriculturally, unless the soils are amended with lime and/or organic matter.

The development of soil acidity is essentially a removal of basic cations by leaching, an accumulation of H^+ ion concentration, and weathering of minerals containing elements toxic to plants. Several factors are involved in the acid infertility of a soil (Kamprath, 1971). Aluminium is a metallic element that exhibits both ionic and covalent bonding. It is the most plentiful of all metallic cations of the earth's crust. It is released from octahedral coordination with oxygen in minerals by weathering, the release of which is quite rapid at pH 4 and below (Kamprath, 1972).

Soluble Al^{3+} appears to be toxic to plants in several ways. It probably has adverse effects on the protoplasm of the cells. Roots and tops alike are stunted severely in the presence of toxic levels of Al^{3+}. The effect on the roots is further characterized by a disorganization of the root cap, the root apex, and the vascular elements (Foy et al., 1978).

Acidity increases as soils are more leached and the soils are lower in the basic cations, Ca^{2+}, Mg^{2+}, Na^{2+} and K^+. Hydrated aluminium ions in solution at a pH