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DEVELOPMENT OF SLOW RELEASE FERTILISERS FOR PINEAPPLE

ELTAIB SAEED MOHAMED GANAWA

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MASTER OF AGRICULTURAL SCIENCE
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BY

ELTAIB SAEED MOHAMED GANAWA

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Dedicated to

' The estimable nucleus in my life who championed my struggled'

Thank you Mother dearest

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Abstract of thesis presented to the Senate of University Putra Malaysia in fulfillment of the requirements for the degree of Master of Agriculture Science

DEVELOPMENT OF SLOW RELEASE FERTILISERS FOR PINEAPPLE

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ELTAIB SAEED MOHAMED GANAWA

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Chairman: Dr Mohamed Hanafi Musa

Faculty: Agriculture

A compound fertiliser was prepared using different types of straight fertilisers from urea (46% N), China phosphate rock (CPR) (32% P_2O_5), muriate of potash (60% K_2O), gypsum (31% CaO), kieserite (27% MgO), and copper sulphate (32% CuO). Granualator machine was used in the preparation of granular compound fertilisers. The compound fertiliser showed high percentage of K and N, 16.31 and 15.05%, respectively and between 0.091 and 4.12% for other elements. The strength of compound fertilisers was measured immediately and after 9 months of the preparation with the values correspond 3.5 and 0.5 Mpa, respectively.

Four types of coating materials were used in the preparation of the slow release compound fertiliser. With the exception of polylactic acid (PLA), the method used for coating of the compound fertiliser with polyacrylamide (PA), polyvinyl chloride (PVC), and natural rubber (NR) were similar. Differential scanning calorimetry (DSC) and thermogravimetry analysis (TGA) studies showed the thermal behavior of the coating materials, and also TGA indicated the temperature at which the degradation of coating materials may occurr. The thickness of different coating material was determined by scanning electronmicroscope (SEM) and the thickest value was obtained using PVC (3.04 μm).

Evaluation of the coated fertilisers was conducted in the laboratory and field. An open leaching experiment in the laboratory indicated that all coating materials were able to reduce the loss of nutrients compared to uncoat fertiliser. The best coating material (PVC) was able to release lower amount of most nutrients (about 77.16% of N added remained in the soil) followed by NR, PLA, and PA. A similar experiment as in the laboratory was performed to evaluate coated fertilisers under natural conditions in UPM Puchong farm. Open leaching experiment in the field indicated that all coating materials were able to reduce the loss of nutrients. Among the coated materials, PVC was able to reduce effectively the loss of nutrients compared to others. This is in agreement with the physico-chemical characteristic of polymer used. Total N loss in the field was about 24% higher than that in laboratory experiment. However, P, K, Ca, and Mg loss were more pronounced in the laboratory than that in the field. The difference in the amounts of N lost for both systems is probably due to the other method of N loss in the field conditions, (such as volatilisation and denitrification of N). Copper lost in both systems was similar, this is due to the behavior of Cu reaction with the soil components.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia bagi memenuhi keperluan untuk ijazah Master Sains Pertanian

PENYDIAAN BAJA-BAJA BEBAS PERLAHAN UNTUK TANAMAN NENAS

Oleh

ELTAIB SAEED MOHAMED GANAWA

Mac 1998

Pengerusi: Dr. Mohamed Hanafi Musa, Ph.D.

Fakulti: Pertanian

Penyediaan baja sebatian dilakukan dengan menggunakan urea (46% N), batuan fosfat China (CPR) (32% P_2O_5), muriate potash (60% K_2O), gipsum (31% CaO), kieserit (27% MgO) dan kuprum sulfat (32% CuO). Mesin pengranulan digunakan dalam penyediaan baja sebatian bergranul. Baja sebatian yang disediakan mengandungi peratus kandungan N dan K yang tinggi masing-masing 16.31 dan 15.05%, dan di antara 0.09 dan 4.12% bagi unsur-unsur lain. Kekuatan fizikal baja sebatian kimia disukat serta-merta setelah disediakan dan selepas 9 bulan dengan nilai masing-masing 3.5 dan 0.5 Mpa.

Sebanyak empat jenis bahan penyalut digunakan bagi menyediakan baja sebatian kimia bebas perlahan. Melainkan asid polilaktik, kaedah yang sama digunakan untuk menyalut baja sebatian kimia dengan poliakrilamid (PA), polivinil klorida (PVC) dan getah asli (NR). Sifat-sifat therma bahan-bahan penyalut dilakukan dengan menggunakan "kalorimetri pengimbasan pembezaan" (DSC) dan "analysis termogravimetri" (TGA), di samping itu TGA

menunjukkan suhu di mana bahan-bahan penyalut boleh terurai. Ketebalan beberapa bahan penyalut ditentukan dengan menggunakan "scanning electron microscope" (SEM) dan nilai yang paling tebal sekali diperolehi dari PVC (3.04 μM).

Penilaian baja-baja sebatian bersalut dijalankan di makmal dan ladang. Satu sistem larutlesap terbuka di makmal menunjukkan kesemua bahan penyalut boleh mengurangkan kehilangan beberapa unsur pemakanan dalam baja sebatian dibandingkan dengan tanpa bersalut. Bahan penyalut terbaik dari PVC boleh mengurangkan pembebasan unsur-unsur pemakanan paling rendah di dalam larutan (contohnya sebanyak 77.2% N masih berada di dalam tanah), kemudian diikuti oleh NR, PLA dan PA. Kajian serupa dengan di makmal dilakukan untuk menilai baja bersalut dalam keadaan semulajadi di ladang UPM, Puchong. Sistem larutlesap terbuka di ladang menunjukkan kesemua bahan penyalut dapat mengurangkan kehilangan unsur-unsur pemakanan. Di kalangan bahan-bahan penyalut, bahan PVC masih juga boleh mengurangkan kehilangan unsur-unsur pemakanan dibandingkan dengan yang lain. Ini adalah selari dengan sifat-sifat kimia fizik polimer yang digunakan. Kehilangan jumlah N di ladang adalah sekitar 24% lebih tinggi dibandingkan dengan di makmal. Walau bagaimanapun, kehilangan unsur-unsur P, K, Ca dan Mg adalah lebih ketara di makmal dibandingkan di ladang. Perbezaan dalam jumlah kehilangan N bagi kedua-dua sistem berkemungkinan disebabkan oleh cara lain bagaiman N boleh hilang di ladang, termasuk melalui pemeruapan dan denitrifikasi N. Kehilangan kuprum sulfat bagi kedua-dua sistem adalah sama dan ini mungkin disebabkan oleh tindakbalas unsur Cu dengan komponen-komponen tanah.

CHAPTER I

INTRODUCTION

Fertilisation is important key to successful pineapple production. The proportion of the total cost incurred by fertilisers varies depending on the intensity of cultivation and on labours. Nevertheless, it always represents a large proportion of total running costs. In Malaysia, pineapples are mainly grown on peat. Smallholders had grown pineapples on deep peat and mineral soils for many years without using fertilisers causing depletion of natural fertility of peat and soil, and consequently the yield declining. To overcome this problem various fertiliser programmes have been put forward by several researchers (Anon., 1956; Grist, 1961). Since the demand of fertiliser by pineapples is high and labour intensive, a new strategy such as slow release fertiliser technology is becoming increasingly important.

Slow-release fertilizers (SRF) are fertilizers made to release their nutrient content gradually, and if possible, to coincide with the nutrient requirements of a plant. Evaluation of the release rate and its mechanism is essential for the selection of the proper fertilizers for a given set of condition or toward the development of proper SRF formulation. The rate of the nutrient release was described by a number of investigators as being controlled by the slow diffusion of the nutrient ions through the membrane to the soil (Ahmed *et al*., 1963; Lunt and Orteli, 1962; Orteli and Lunt, 1962). As such, the process is deterministic and equal to all the SRF granule population. Kochba *et al.* (1990) proposed the mechanism leading to the nutrient release. This is caused by the diffusion of water vapor into the granule through the hydrophilic membrane and the subsequent bursting or expansion of the membrane, both leading to an accelerate outward flow of the saturated solution from the coated granule. Timing of the nutrient release of the individual granules was considered to be a random phenomenon described by first-order kinetics i.e., similar to radioactive decay.

A number of SRF formulations have been developed during the last decades (Hauke, 1995). This trend is motivated by the effort to produce and apply fertilisers so the crop nutrient needs are satisfied while a minimum of fertiliser salts is leached or wasted. This reasoning is valid for economic consideration (i.e., maximising utilisation of added fertiliser) and, even more, to minimising fertiliser leaching.

The use of hydrophilic polymers with fertilisers offers concept for controlling nutrient release in soil. Further work remains to be done on the exact nature of the polymer and nutrient interaction. Cooperation with polymer chemical, modification of the polymer structure should be made to optimise the nutrient release pattern to fit specific crop needs. By modifying the polymers, properties such as enhance ion retention, biodegradation rate, and adverse salts effect can be manipulated to correspond with desire nutrients release rates. The side benefits of hydrophilic polymers, such as increased moisture retention and improves physical conditions of soil need to be systematically quantified. Low cost polymers should be further explored to identify promising carriers that can be used at an affordable price. Further research is also needed on field application equipment that would allow precise placement of the nutrient containing polymers into the soil. Carefully designed field experiments are needed to determine the value of the polymer technology in improving nutrient recovery in a variety of agricultural conditions. Using polymers to supply plant nutrients may provide an additional method of providing nutrients in controlled manner to more accurately meet the crop needs while protecting the quality of the environment and conserving natural resources.

One of the main causes for nutrient losses is through leaching and this is particularly serious in sandy soil and in areas of high rainfall or intensive irrigation. Chemical instabilities, such as volatilisation of ammonia from urea and ammonium containing fertilizers or conversion of relatively immobile NH_4^+ to mobile NO_3^- and its subsequently denitrification to N_2 and N_2O are other causes for nutrient loss. Therefore, losses of fertilizers whether through leaching, chemical instabilities or by any other means make their use quite costly. Repeated fertilizers are therefore necessary to replenish the losses. A single heavy application of higher than normal quantity to avoid repeated applications is not advisable as it may cause salt injury to the plant. Apart from losses, the hygroscopic nature of much conventional fertiliser creates both handling and storage problems.

Considerable efforts are being directed to minimise the losses of nutrients from water-soluble fertilizers. One approach is to develop fertilizers which will dissolve slowly enabling only a small quantity of nutrients to be released at any one time to the growing plant. This may be achieved by synthesising fertilisers with slow rate of dissolution as in the cause of condensation reaction of urea with various aldehydes (Hays and Hadden, 1969). Quastel (1965) also stated that fusing micronutrients with large amount of silicate, loss of nitrogen through denitrification could be reduced by chemically inhibiting the nitrifying organism. A third approach is to encapsulate or coat granulated fertilisers with a film of insoluble material such plastic, resin, synthetic fibre, glass, wax, gum, asphalt etc. Coated fertilisers can delay the rate of release of nutrients (Soong *et al.*, 1977), and have advantages over other type of SRF also can be obtained without undergoing any chemical reaction. However, because of the high cost of the coating materials most of coated fertilisers have limited commercials production and are relegated to specific uses for cultivation of turf and ornamentals. The production of SRF by the encapsulation process, although technically feasible, depends very much on the availability of effective coating materials.

Objectives

The present project is focused on the development of slow release fertiliser for the pineapple and the aims of the current project are:

1. To prepare compound fertilisers which is suitable for pineapple production.
2. To coat the compound fertiliser with different types of polymers.
3. To study the performance of the coated fertiliser with polymers, using leaching technique.

CHAPTER II

LITERATURE REVIEW

Fertiliser burn, fast leaching, and surface runoff are several shortcoming of normal chemical fertilisers. Extensive efforts have been undertaken to search for a new type of fertiliser that can overcome these disadvantages. Since the 1960s the United States, Japan and some European countries have taken the lead in manufacturing such new fertiliser. They are chemically compound fertilisers or controlled-release fertiliser. Thus far, many of the Slow Release Fertiliser (SRF) have been manufactured and tested on various crops.

Types of Slow-Release Fertiliser

The term 'controlled-release fertiliser' or 'slow-release fertiliser' refers to a fertiliser that for any reason release its nutrient contents over an extended period or release plant nutrients slowly throughout a growing season or even several continuous growing season (Hinget, 1974). In other words, slow-release fertiliser are the ones that release their plant nutrients at a rate which possibly permits maximum plant uptake and reduces minimally nutrient loss due to leaching and surface runoff (Tajudin, 1979).