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INFLUENCE OF SLOW-RELEASE FERTILISERS ON GROWTH OF RUBBER (HEVEA BRASILIENSIS) SEEDLINGS

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By

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LIST OF ABBREVIATIONS

a.e.	Atom excess
AB	Agroblen
ANOVA	Analysis of variance
BT	Best Tab
CON	Control treatment
DAI	Day after incubation
DAP	Day after planting
DF	Degree of freedom
F	F distribution
FNY	Fertiliser nitrogen yield
FUE	Fertiliser utilisation efficiency
KN	Kokei Nugget
LAS	Labelled ammonium sulphate
MS	Mean of squares
NA	Nurseryace
Ndff	Nitrogen derived from fertiliser
NY	Nitrophoska Yellow
RRIM	Rubber Research Institute of Malaysia
RRIV	Rubber Research Institute of Vietnam
SRF	Slow-release fertiliser
SS	Sum of squares
UPM	Universiti Putra Malaysia

Abstract of the Thesis Presented to the Senate of Universiti Putra Malaysia in Fulfilment of the Requirements for the Degree of Master of Agricultural Science

INFLUENCE OF SLOW-RELEASE FERTILISERS ON GROWTH OF RUBBER *(Hevea Brasiliensis)* **SEEDLINGS**

By

TONG VIET THINH

June, 1997

Chairman: Prof. Dr. Sharifuddin Haji Abdul Hamid
Faculty: Agriculture

Rubber, *Hevea brasiliensis*, is a valuable crop of some countries in Asia. In the rubber industry, fertiliser application is one of the most effective methods to enhance growth of rubber seedlings in the nursery. However, application of chemical fertilisers has several disadvantages such as fast nutrient leaching, fertiliser burn and requirement of intensive labour for split applications. In recent years, slow-release fertilisers have been introduced to solve the above problems on many crops including rubber. Studies on the effect of slow-release fertilisers on rubber are limited and there has been no work reported on the use of isotope technique to accurately study nutrient uptake and efficiency of fertilisers use.

This study was set up with the aim of studying the rate of nutrient release of slow-release fertilisers and their effect on the performance of rubber seedlings using ^{15}N isotope dilution technique. Two experiments, namely, laboratory incubation and glass-house experiments were conducted. Five fertilisers were evaluated, four of which were slow-release fertilisers (Agroblen, Best Tab, Kokei Nugget and Nurseryace) and one conventional chemical fertiliser (Nitrophoska Yellow). In the soil-incubation experiment, Bungor and Sungai Buloh series soils were used, while in the glass-house experiment, only Bungor series soil was used

Results from the incubation experiment showed that during the period of incubation, Nitrophoska Yellow gave the fastest rate of fertiliser decomposition and NPK release, while Nurseryace were persistently the lowest. Higher fertiliser decomposition and release of N and K were obtained in Bungor series soil as compared to Sungai Buloh series soil. However phosphorus release in Bungor series soil was lower than that in Sungai Buloh series soil. It was found that there was a very close relationship between fertiliser decomposition and NPK release of slow-release fertilisers, particularly for Kokei Nugget and Nitrophoska Yellow.

In the glass-house experiment, evaluation at 180 days after planting showed that among the four slow-release fertilisers applied, Best Tab gave the highest growth and also gave the highest nitrogen uptake, total uptake of N, P, K, Ca and Mg, and fertiliser utilisation efficiency. Meanwhile, Nitrophoska Yellow gave the lowest values of fertiliser nitrogen yield, fertiliser utilisation efficency as well as total nutrient uptake.

The results obtained from the two experiments showed that Best Tab slow-release fertiliser is the best fertiliser as compared to the other slow-release fertilisers tested under the conditions of the study.

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PENGARUH BAJA LEPASAN PERLAHAN TERHADAP PERTUMBUHAN ANAK BENIH POKOK GETAH

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Pokok getah, *Hevea brasiliensis*, adalah tanaman bernilai di beberapa negara Asia. Dalam industri getah, pembajaan adalah kaedah yang berkesan untuk meningkatkan pertumbuhan anak benih getah di tapak semaian. Walau bagaimanapan penggunaan baja kimia mempunyai beberapa masalah saperti larutlesap nutrien yang cepat, pemeruapan baja, keperluan membaja dengan kerap dan keperluan buruh yang tinggi. Kebelakangan ini, baja lepasan perlahan telah diperkenalkan bagi menyelesaikan masalah yang dinyatakan di atas bagi kebanyakan jenis tanaman termasuk getah. Kajian kesan baja lepasan perlahan ke atas getah adalah terhad dan sehingga keni, laporan mengenai penggunaan teknik isotop bagi mengkaji pengambilan nutrien dan keberkesanan baja oleh getah juga tidak di depati.

Kajian ini adalah dijalankan untuk mengkaji kadar lepasan baja lepasan perlahan, dan pengambilan nitrogen untuk perkembangan anak benih getah dengan menggunakan teknik pencairan isotop ^{15}N. Kajian ini melibatkan dua eksperimen, iaitu eksperimen pengeraman dan eksperimen rumah kaca. Lima jenis baja telah dinilai, empat daripadanya adalah baja lepasan perlahan (Agroblen, Best Tab, Kokei Nugget dan Nurseryace) dan satu baja kimia biasa iaitu Nitrophoska Kuning. Dalam eksperimen pengeraman, tanah siri Bungor dan siri Sungai Buloh telah digunakan manakala dalam eksperimen rumah kaca, hanya tanah siri Bungor digunakan.

Keputusan yang diperolehi daripada eksperimen pengeraman telah menunjukkan baja Nitrophoska Kuning menghasilkan kadar penguraian baja dan pelepasan NPK yang paling cepat. Sementara itu, Nurseryace merupakan yang paling lambat. Di antara kedua jenis tanah, siri Bungor telah mempamirkan penguraian baja dan pembebasan N dan K yang lebih cepat berbanding dengan tanah siri Sungai Buloh, manakala pembebasan P pula adalah lebih tinggi bagi tanah siri Sungai Buloh berbanding dengan tanah siri Bungor. Terdapat perhubungan yang baik di antara penguraian baja dan pembebasan NPK terutamanya oleh Kokei Nugget dan Nitrophoska Kuning.

Dalam ekperimen rumah kaca, penilaian pada hari ke 180 selepas penananam telah mendapati bahawa Best Tab memberikan pertumbuhan yang paling tinggi dan menghasilkan pengambilan nitrogen, jumlah pengambilan N, P, K, Ca dan Mg, dan keberkesanan penggunaan baja yang paling tinggi. Dalam pada itu, pengambilan nitrogen dan keberkesanan pembajaan bagi Nitrophoska Kuning adalah yang paling rendah.

Berdasarkan keputusan dari kedua-dua ekperimen, didapati bahawa Best Tab merupakan baja lepasan perlahan yang paling baik berbanding dengan lain-lain baja lepasan perlahan yang dikaji.

CHAPTER I

INTRODUCTION

Slow-release or controlled-release fertiliser (SRF) is a special chemical compound fertiliser that releases its nutrients slowly and safely for plants. So far, only some countries have manufactured slow-release fertilisers, such as, Japan, United States of America, Netherlands and Switzerland. In slow-release fertiliser applications, generally, the amount of nutrient required for plant is bulk-applied to soil at only one application per year. The slow-release fertiliser can maintain its nutrients and functions in soil from a few months up to a few years depending on the manufacturing process of manufacturers. It has been reported that, though slow-release fertilisers were applied with a single application, they gave minimum nutrient leaching, no fertiliser burn, satisfactory nutrient supply and high performance on growth of plants. Because of these advantages, slow-release fertilisers have been and will hopefully become a promising new generation of fertiliser for use in various crops.

In rubber (*Hevea brasiliensis*) cultivation it is well known that the quality of seedlings or stocks in the nursery will determine the crop performance in the field, and that fertiliser application is one of the most effective methods to enhance growth of rubber seedlings. Currently, chemical fertilisers are used in the rubber nursery which may result in fertiliser burn of roots, rapid nutrient leaching in soil, as well as higher labour demand for split applications.

In view of its controlled nutrient release properties, slow-release fertilisers are greatly expected to overcome the problems imposed by conventional fertilisers. In recent years, many different kinds of slow-release fertilisers have been made available in the market, and each of them was recommended for certain crops. Nevertheless, actual efficiency of slow-release fertilisers on growth of crops, including rubber seedlings, have not been shown to be satisfactory. In other words, in order to identify proper kinds of slow-release fertiliser for rubber seedlings, intensive studies in this area is required.

At present, in Asian countries, slow-release fertilisers are neither popular nor widely used due to their high cost, and therefore, there have been few slow-release fertiliser trials Besides, on a global scale, to date only a few slow-release fertiliser studies have been done on rubber trees, and there was absolutely no slow-release fertiliser investigation which employed isotope technique to study nutrient uptake and fertiliser efficiency Due to this and on the basis of some slow-release fertilisers available for nursery plants, this project was conducted using ^{15}N isotope dilution technique to

1) study the release rate of slow-release fertilisers on two types of Malaysian soils,

2) determine the efficiency of nutrient uptake from slow-release fertilisers by rubber seedlings, and

3) evaluate the influence of slow-release fertilisers on the performance of rubber seedlings.

CHAPTER II

REVIEW OF LITERATURE

Due to the shortcomings of normal chemical fertilisers, such as, fertiliser burn, fast leaching, and surface runoff, 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 fertilisers. They are chemically compound fertilisers and usually called slow-release fertilisers or controlled-release fertilisers. Thus far, many of SRF have been manufactured and tested on various crops.

Classification of Slow-release Fertilisers

For slow-release fertilisers, efforts to achieve controlled availability of applied nutrients has been centred in two major areas. One was through controlled release either by using slowly soluble compounds or by coating soluble compounds with an insoluble or inert material. Coated materials will gradually be decomposed followed by slow nutrient release. A second area was through protected availability. This was designed to keep the nutrients in a form that is readily available to crops but partially protected from immobilisation or nitrification in the soil system, especially in anaerobic condition. Nitrification inhibitors are included in this area (Stangel, 1970).

The term 'controlled-release fertiliser' or 'slow-release fertiliser' refers to a fertiliser that for any reason releases its nutrient contents over an extended period or releases plant nutrients slowly throughout a growing season or even several continuous growing seasons (Hignett, 1974). In other words, slow-release fertilisers 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 (Tajuddin, 1979).

Slow-release fertilisers contain one or more of the popular plant nutrients, such as N, P, K and sometimes some additional micro-nutrient elements. However, in practice, the need for a slow-release nitrogen fertiliser is more acute than for phosphate, potash or micro nutrient elements (Hignett, 1974). Hence, the manifold of slow-release fertilisers mainly comes from nitrogen fertilisers . Three main groups of slow-release fertilisers are slowly soluble fertilisers, coated fertilisers, and nitrification inhibitor-mixed fertilisers.

Slowly Soluble Fertilisers

Slowly soluble fertilisers are chemical compounds that are only slightly soluble in water and usually made by reacting water-soluble fertilisers with inert materials (Tajuddin, 1979). Most slowly soluble fertilisers are related to urea. For this kind of slow-release fertiliser, urea component is often included, for example, Best Tab, CDU (cyclodiurea), FU (2 furfurilidene 3 urea), Glycoluril, IBDU (isobutyliden diurea), Nurseryace, Urea-Z (mixtures of ethylene ureas), Ureform (urea-formaldehyde).

The general process of making slowly soluble fertilisers were reported as follows: i) Water-soluble nitrogen sources are reacted chemically with an inert chemical at a required ratio and temperature; ii) After that, before cooling and solidifying, the mixture is divided into desired particles in a granule-maker; iii) With different inert chemicals, ratios and particle sizes, different types and characters of slowly soluble fertilisers are manufactured (Abad *et al.*, 1989; Guyot *et al.*, 1990; Riemenschneider, 1984)

Coated Fertilisers

So far, coated fertilisers have been popular with the well-known brands available in the market, such as Agriform, Agroblen, Basacote, Ficote, Gold-N (sulphur-coated urea), Lewatit, Nutricote, Osmaform, Osmocote, Plantacote, Plantosan, Vitamon. A wide range of materials and techniques have been explored to produce more and more effective controlled-release fertilisers. Numerous covering materials were used for such slow-release fertilisers, for instance, plastic films, resins, waxes and other barriers. The most popular coating material was a copolymer of dicyclopentadien and glycerol ester. This material allows for a fertiliser-nutrient release based on osmotic exchange as the material comes in contact with soil water. Coated granular fertilisers were manufactured by Archer Daniels Midland company (ADM Co.) under the trade name Osmocote from 1964, and since 1974 they have been manufactured and marketed by Sierra Chemical Company under exclusive licensing from ADM Company. Osmocote was recommended for nursery stocks, turf, floriculture and high-value row crops (Powell, 1968).

According to Mahara *et al.* (1992), coated granular fertilisers essentially consist of fertiliser granules that are selected from urea, ammonium sulphate, ammonium chloride, ammonium nitrate, potassium chloride, potassium sulphate, potassium nitrate, sodium nitrate, ammonium phosphate, potassium phosphate or calcium phosphate, which are covered on the outside with a copolymer coat in 5-40% (w/w) ratio. The copolymer comprises units of vinyl chloride and ethylene in a proportion of 50:50 - 90:10 by weight

Sulphur-coated urea (SCU) is another controlled-release fertiliser that has been developed by Tennessee Valley Authority (TVA) since the 1960s