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LITTERFALL, THROUGHFALL AND STEMFLOW IN ACACIA MANGIUM STANDS ON TIN TAILINGS AND THEIR EFFECTS ON SOIL CHEMICAL PROPERTIES

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LITTERFALL, THROUGHFALL AND STEMFLOW IN *ACACIA MANGIUM* STANDS ON TIN TAILINGS AND THEIR EFFECTS ON SOIL CHEMICAL PROPERTIES

By

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THIS WORK IS DEDICATED TO

MY LATE FATHER---SREE RAM BILAS PRASAD

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Faculty: Forestry

Acacia mangium has been planted on ex-tin tailing areas to improve soil fertility. The return of macro nutrients from *A. mangium* and their effects on the soil chemical properties is however not well understood. The main objective of this study is to compare the effects of macro nutrient input via *A. mangium* litter, throughfall and stemflow on soil chemical properties of mineral and ex-tin mining soils.

The first study area located in mineral soil situated in Universiti Pertanian Malaysia farm consists of an *A. mangium* covered plot (AMA) and a grass covered plot (GCA). The second study area on ex-tin mine soil located in Semenyih, Selangor, consists of an *A. mangium* covered plot (AMB) and a grass covered plot (GCB).

The total annual litter production for AMA is 872.51 g/m^2 and 741.18 g/m^2 for AMB. The litter production of AMA is

significantly ($P<0.01$) higher than that of AMB. At AMA, the annual return of nutrients through litterfall are 9.48 g/m^2 N, 0.33 g/m^2 P, 3.13 g/m^2 K, 6.27 g/m^2 Ca and 1.90 g/m^2 Mg. At AMB, it is 8.09 g/m^2 N, 0.28 g/m^2 P, 2.71 g/m^2 K, 5.38 g/m^2 Ca and 1.62 g/m^2 Mg.

The mean ground leaf litter biomass is 516 g/m^2 for AMA and 458.68 g/m^2 for AMB.

The mean weekly decomposition rate of leaf litter is 1.6% at AMA and 1.5% at AMB.

Throughfall, stemflow and interception average 59.7%, 2.9%, and 39.7% of gross rainfall at AMA, while at AMB, the corresponding percentages are 57.6%, 2.7% and 39.8% . The total quantity of nutrients added annually to each hectare of the soil through precipitation, throughfall and stemflow is 6.68 kg of N, 0.42 kg of P, 10.26 kg of K, 1.19 kg of Ca and 0.59 kg of Mg for AMA, while for AMB, it is 5.95 kg of N, 0.28 kg of P, 9.14 kg of K, 0.91 kg of Ca and 0.52 kg of Mg.

The litter produced and crown leaching nutrients also improved the soil nutrient status in AMA compared to GCA by the following changes in mean concentrations: organic matter, 1.3% ; N, 0.64 mg/g; P, 4.50 ppm; K, 0.51 ppm; Ca, 0.10 ppm and Mg, 0.09 ppm. In AMB, the improvement in organic matter is 0.3% ; N, 0.27 mg/g; P, 0.65 ppm; K, 0.03 ppm; Ca, 0.03 ppm and Mg, 0.01 ppm.

Abstrak tesis yang dikemukakan kepada Senat Universiti Pertanian Malaysia untuk memenuhi syarat ijazah Master Sains.

GUGURAN-SARAP, CURAHAN-TERUS DAN ALIRAN-BATANG DALAM DIRIAN *ACACIA MANGIUM* DI ATAS BEKAS LOMBONG BIJIH TIMAH SERTA KESANNYA TERHADAP SIFAT KIMIA TANAH

OLEH

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A. mangium telah ditanam di kawasan bekas lombong bijih timah untuk memperbaiki kesuburan tanah. Pulangan nutrien makro daripada *A. mangium* dan kesan mereka terhadap sifat kimia tanah bagaimanapun tidaklah diketahui secara mendalam. Objektif utama kajian ini ialah untuk membandingkan kesan input nutrien makro melalui sarap, curahan-terus dan aliran-batang *A. mangium* terhadap sifat kimia tanah bagi tanah mineral dan bekas lombong bijih-timah.

Kawasan kajian yang pertama terletak di tanah mineral di ladang Universiti Pertanian Malaysia, mengandungi petak diliputi *A. mangium* (AMA) dan petak dilitupi rumput sahaja (GCA). Kawasan kajian kedua di tanah bekas lombong bijih timah di Semenyih, Selangor, mengandungi petak diliputi *A. mangim* (AMB) dan petak diliputi rumput sahaja (GCB).

Jumlah penghasilan tahunan guguran sarap bagi AMA ialah 872.51 g/m^2 dan 741.18 g/m^2 bagi AMB. Penghasilan sarap bagi AMA adalah lebih tinggi (bererti pada $P<0.01$) berbanding dengan AMB. Pada AMA, pulangan tahunan nutrien melalui guguran sarap ialah 9.48 g/m^2 N, 0.33 g/m^2 P, 3.13 g/m^2 K, 6.27 g/m^2 Ca dan 1.90 g/m^2 Mg. Pada AMB, ianya adalah 8.09 g/m^2 N, 0.28 g/m^2 P, 2.71 g/m^2 K, 5.38 g/m^2 Ca dan 1.62 g/m^2 Mg.

Purata biojisim sarap daun di tanah ialah 516.13 g/m^2 bagi AMA dan 458.68 g/m^2 bagi AMB.

Purata penguraian mingguan bagi sarap daun ialah 1.6% di AMA dan 1.5% di AMB.

Purata curahan-terus, aliran-batang dan pemintasan ialah 59.7%, 2.9%, and 39.7% daripada hujan secara kasar pada AMA, manakala pada AMB, peratusan yang sepadan ialah 57.6%, 2.7% dan 39.8% . Jumlah kuantiti nutrien bertambah pada setiap hektar tanah setahun melalui curahan hujan, curahan-terus dan aliran-batang ialah 6.68 kg N, 0.42 kg P, 10.26 kg K, 1.19 kg Ca dan 0.59 kg Mg di AMA, manakala di AMB, ianya adalah 5.95 kg N, 0.28 kg P, 9.14 kg K, 0.91 kg Ca dan 0.52 kg Mg.

Sarap yang dihasilkan dan larutanlesap nutrien dari silara juga memperbaiki status nutrien tanah pada AMA berbanding dengan GCA pada perubahan purata kepekatan seperti berikut: bahan organik, 1.3% ; N, 0.64 mg/g; P, 4.50 ppm; K, 0.51 ppm; Ca, 0.10 ppm dan Mg, 0.09 ppm. Pada AMB, pembaikan bahan organik ialah 0.3%; N, 0.27 mg/g; P, 0.65 ppm; K, 0.03 ppm; Ca, 0.03 ppm dan Mg, 0.01.

CHAPTER I

INTRODUCTION

Green plants are the primary producers of organic matter through the process of photosynthesis. All forms of life are dependent upon these primary organic materials which are used for various metabolic activities (George, 1982). A substantial portion of the accumulated nutrients in the plant biomass is returned to the soil primarily through litterfall and rainfall by way of stemflow and throughfall. Addition of N, P, and K to the soil mainly occur through litterfall while throughfall, however, accounts for most of K and Mg inputs to the soil (Parker, 1983). Nutrients in litterfall are more slowly released into the soil from organic matter than those from throughfall and stemflow which are in ionic form and are either easily absorbed by plant or quickly leached away in the soil (Parker, 1983). Rapid decomposition of plant litter at the onset of the rainy season, however, usually enhances major increases in nutrient accumulation over a relatively short period (Swift *et al.*, 1981). Hence, litterfall and canopy leaching are important in that they are the two principal routes by which mineral nutrients are cycled rapidly within the forest ecosystem. The study of the quantitative aspect of nutrient status of litter, litter production, litter accumulation, litter decomposition and nutrient leaching from canopy via stemflow and throughfall is therefore an important one, as these processes are the major pathways for nutrient transfer in forest ecosystem (Parker, 1983).

A number of studies have been conducted on litter production, accumulation and decomposition (Anderson *et al.*, 1983; Lim, 1988; and Scott *et al.*, 1992) and the leaching of nutrients via throughfall and stemflow (Manokaran, 1980; Parker, 1983; Bellot and Escarre, 1991). However, there is little information of such studies conducted in ex-tin-mining areas. Work on nutrient cycling of vegetation planted in tin-tailing areas is also relatively new.

Panton (1964), Wong (1970) and Kho (1979) estimated that there were 120,000, 180,000, and 200,000 hectares of tin-tailings in Peninsular Malaysia. Based on these estimates, it was assumed that the tin-tailing areas in the country during the 1980's increased at an average rate of more than 4,000 hectares per year (Lim and Maesschalck, 1980).

Acacia mangium Willd., a fast-growing leguminous tree species, has a wide edaphic tolerance (NRC, 1983). It has been reported to have great potential as a plantation crop in sand, loamy sand or coarse sandy loam (such as in degraded areas) (NRC, 1983). It is also one of the most widely planted fast-growing exotic tree throughout Peninsular Malaysia (Yong, 1984).

Acacia mangium is indigenous to Australia, Papua New Guinea and Indonesia. This species grows rapidly and has a high productivity of 18.3 tonnes/ha/yr (Lim, 1986). It is also capable of overcoming strong competition from the common grass, *Imperata cylindrica* and flourishes on degraded areas (NRC, 1983). It can grow up to 23 m after nine years with stem diameter up to 23 cm (Tham, 1976). It is a multipurpose tree, suitable for timber, molding, furniture, fire wood and pulp (NRC, 1983).

The area of forest plantations in the tropics is increasing rapidly following population growth and the associated rising demands for fuel, construction and pulp wood, (Bruijnzeel, 1989). However, recently, concern has been expressed about the effects that fast-growing tree plantations with their often high nutrient demands may have upon soil nutrient reserves and therefore on future productivity, especially when grown on poor soils and in short rotation (Bruijnzeel, 1989). The question of how the forests survive in the nutrient-poor environment has interested ecologists for many years, and it has been hypothesized that nutrient conserving mechanisms have evolved in these ecosystems to enable these forests to survive and grow in this nutrient-poor environment (Richard, 1952).

Despite the growing significance of tropical plantations as ecosystems, the water and nutrient dynamics of forest plantations have received little attention as compared to natural forests in the tropics (Jordan, 1985). Similarly, less emphasis has been given to nutrient dynamics in *Acacia mangium* plantations in Malaysia. In view of the importance of nutrient dynamics in the tropics, this study attempts to evaluate the nutrient status of litter, litter production, litter accumulation, the rate of decomposition, throughfall, stemflow, nutrients in throughfall and stemflow and their effects on both ex-tin-tailing and ordinary mineral soil planted with *Acacia mangium* trees.

The specific objective is :

To compare the effects of macro nutrient elements input via *Acacia mangium* litter, throughfall and stemflow on soil chemical properties of mineral soil and ex-tin-tailing soil.

The general objectives are:

i. To compare litter production, accumulation, litter decomposition rate and the percentage of throughfall and stemflow between sites.

ii. To compare the quantity of macro nutrients released from *Acacia mangium* stands via litterfall, throughfall and stemflow to the forest floor.

It is hoped that, with this study, the nutrient conserving mechanism, especially transfer of nutrients from *A. mangium* stand via litterfall, throughfall and stemflow to the forest floor could be understood better and improvements to the soil and the productivity of the stands be made.

CHAPTER II

LITERATURE REVIEW

This chapter deals with literature related to this study. These are: litter production, accumulation, decomposition and return of nutrients via litterfall. Including pattern of forest influence on the rainfall interception, throughfall, stemflow components through the forest canopy and their nutrient return.

Litter Production

Plant litter is often defined as dead material lying on the soil surface comprising of dead plants and shed organs, but not standing dead matter (Medwecka-Kornas, 1971). Rodin and Bazillevitch (1967) included all dead organic matter from above- and below-ground plant parts as including flowers, leaves, seeds, fruits and small twigs. Roots are generally disregarded and this can cause some problems especially in desert environment where the underground litter from aerial plants could be an important component of desert ecosystem (Holmgren and Brewster, 1972).

Litter can be divided into two types, fine and coarse litter. Leaves, twigs, branches (less than 2 cm diameter) and other fine/small miscellaneous components are regraded as fine litter while coarse litter includes big branch and stems. In