UNIVERSITI PUTRA MALAYSIA

# NUTRIENTS UPTAKE AND CYCLING OF PINEAPPLE PLANTED ON TROPICAL PEAT

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# NUTRIENTS UPTAKE AND CYCLING OF PINEAPPLE PLANTED ON TROPICAL PEAT

By

**OSUMANU HARUNA AHMED**

Thesis Submitted in Fulfilment of the Requirements for the Degree of Master of Agricultural Science in the Faculty of Agriculture, Universiti Putra Malaysia.

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## DEDICATION

This thesis is dedicated to the contributors and the potential contributors to any kind of knowledge that is beneficial to humanity or mankind and is as well in harmony with nature.

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# TABLE OF CONTENTS

# LIST OF TABLES

## LIST OF FIGURES

Abstract of thesis submitted to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the Degree of Master of Agricultural Science.

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**Faculty : Agriculture**

The obectives of the study were: (i) To quantify the dry matter production and nutrients uptake under burnt and unburnt pineapple residue management practices, (ii) To determine the nutrients capacity and intensity of tropical peat under pineapple cultivation, (iii) To quantify the movement of nutrients in pineapple production system, and (iv) To conduct economic valuation of the burnt and unburnt pineapple residue management practices.

Treatments used were: (i) Leaves residue removed and no fertilization, (ii) Leaves residue burnt and no fertilization, (iii) Leaves residue removed and fertilization, and (iv) Leaves residue burnt and fertilization. The experimental unit was individual plant planted in 4 m x 12 m plot. Altogether 300 pineapple plants were planted in this plot having a randomized complete block design (RCBD) with

4 replications. Phosphorus and K were applied in the forms of China phosphate rock and muriate of potash at the rates of 35.56 P and 556.56 K kg/ha. At maturity, 3 plants were sampled from each treatment and partitioned into roots, stem, leaves, fruit, crown and peduncle and their dry weight, P, K, Ca and Mg concentrations determined.

Soil sampling at the depths of 0-5, 5-25 and >25 cm was done before, during and after fertilization stages. Soil solution P, K, Ca and Mg; extractable P, K, Ca and Mg; and total P, K, Ca and Mg were extracted using the squeeze, double acid and dry ashing methods, respectively. The subtraction method was used to estimate P, K, Ca and Mg leached.

Average weight of fruit for the treatments i.e. leaves residue removed and fertilization and leaves residue burnt and fertilization were determined from 100 fruits. The weight multiplied by plant density gave total yield/ha. The product of the total yield/ha and farm-gate price gave the gross revenue of crop production. Cost of labour was based on the wage system practiced by the estate. Farm-gate market prices were used for farm materials and other inputs. Interest rate of 12% on capital was adopted. Polluter Pay Principle, the Malaysian Environmental Quality (Clean Air) Regulations, 1978 on burning of waste and Air Pollutant Index (API) were used to value pollution. Land Expectation Value (LEV) was used to compare the viability of the two practices.

Irrespective of treatment difference, P, and Mg distribution was highest in fruit, followed by leaves, stem, crown, peduncle and roots. The order for K was fruit, leaves, stem, peduncle, crown and roots. The sequence for Ca was leaves, stem, fruit, crown, peduncle and root for the unburnt and burnt without fertilization while that of the unburnt and burnt with fertilization was stem, leaves, fruit, crown, peduncle and root. Due to low nutrient recovery, the addition of 1.31 Mg/ha ash increased P, K, Ca and Mg uptake and yield insignificantly. Major difference in P efficiency for burnt (51.60%) and unburnt (53.21%) under fertilized condition was not observed and that of K was approximately 6% higher under burnt (36.09%) than unburnt (29.91%).

Besides high buffering capacity, significant correlation between the capacity to supply P, K, Ca and Mg and those of intensity (P, K, Ca and Mg) under fertilized condition than the unfertilized condition was observed.

Phosphorus, K, Ca and Mg movement in pineapple production system identified were - input (fertilizer, ash and precipitation), loss (fruit, leaves residue removal, leaching and runoff), uptake and return, and nutrient retention. In terms of inputs, fertilizer contributed the highest amounts of P, K, and Ca. Ash contributed the highest amount of Mg under the burnt practice. Leaching constituted the single major source of P, K, Ca and Mg loss for both the burnt and unburnt practices due to excessive fertilization and high precipitation. With the exception of Mg, where input and output were approximately the same for the unburnt practice, a positive

balance at the end of cropping was recorded for P, K, Ca and Mg under the burnt practice and P, K and Ca for the unburnt practice.

The gross revenue of pineapple production under burning increased by RM 90.00 upon the addition of 1.31 Mg/ha ash. Pollution and land preparation (burning leaves versus removal of leaves) were the sole contributors of the difference in the total cost of production and the incremental net benefit as a whole for the burnt and unburnt practices. Burning is economically viable under the fine of RM 10,000.00 but with the current fine of RM 500,000.00, it is not a viable practice. The implication of the study is that, the pineapple industry may fold up if a better alternative of burning is not sought to. Therefore zero-burning or value addition approaches needs urgent pursuance.

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

**PENGAMBILAN DAN PENGITARAN NUTRIEN OLEH NENAS YANG DITANAM DI TANAH GAMBUT TROPIKA**

Oleh

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**Februari 1999**

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Objektif kajian yang dijalankan ialah untuk: (i) Menghitung pengambilan P, K, Ca dan Mg pada bahagian-bahagian pokok nenas dan menilai keberkesanan penggunaan P dan K pada keadaan apabila sisa dibakar berbanding dengan keadaan apabila sisa tidak dibakar, (ii) Menentukan hubungan antara kebolehan untuk membekalkan P, K, Ca dan Mg akibat pembajaan berbanding dengan apabila tiada pembajaan, (iii) Menghitungkan input, kehilangan, baki dan pulangan pada keadaan di mana sisa nenas dibakar berbanding dengan apabila tidak dibakar, dan (iv) Membandingkan kos dan pulangan antara kaedah pengurusan berteraskan pembakaran sisa nenas dengan tanpa pembakaran sisa nenas.

Rawatan yang dilakukan adalah: (i) Pembuangan sisa daun dan tiada pembajaan, (ii) Pembakaran sisa daun dan tiada pembajaan, (iii) Pembuangan sisa

daun dan diikuti oleh pembajaan, dan (iv) Pembakaran sisa daun dan diikuti oleh pembajaan. Pokok nenas individu, yang ditanam dalam plot bersaiz 4 m x 12 m, dianggap sebagai unit eksperimen. Sejumlah 300 anak pokok nenas ditanam dalam plot eskperimen dan disusun mengikut rekabentuk rawak blok sepenuhnya (RCBD) dengan 4 replikasi. Fosforus dibekalkan dalam bentuk batuan fosfat China pada kadar 35.56 P kg/ha manakala K dibekalkan dalam bentuk 'muriate of potash' (MoP) pada kadar 556.56 K kg/ha. Pada peringkat matang, 3 pokok disampel dari setiap rawatan dan sampel diagihkan kepada bahagian-bahagian akar, batang daun, buah, "crown" dan "peduncle". Ini disusuli dengan penentuan berat kering, dan kepekatan unsur-unsur P, K, Ca dan Mg.

Persampelan tanah pada kedalaman 0-5 cm, 5-25 cm dan >25 cm dilakukan sebelum, semasa dan selepas pembajaan. Larutan tanah, kandungan P, K, Ca and Mg total dan tersedia masing-masing di ekstrak menggunakan kaedah perahan, kaedah dwi-asid dan kaedah pengabuan kering. Kaedah substraksi digunakan untuk menganggarkan amaun P, K, Ca and Mg yang larut resap.

Purata berat bahagian buah untuk rawatan iii and iv ditentukan daripada sejumlah 100 buah. Berat buah didarabkan dengan densiti pokok untuk mendapatkan jumlah hasil per hektar. Jumlah hasil per hektar serta harga ladang memberikan pulangan kasar pengeluaran tanaman. Kos buruh adalah berdasarkan sistem gaji yang dipraktikkan oleh pihak pengurusan estet. Peralatan ladang dan lain-lain input adalah berdasarkan harga ladang di pasaran. Kadar cengkeram sebanyak 12% dikenakan terhadap modal. Prinsip 'Pencemar Membajar', Akta Kualiti Alam Sekitar (Udara Bersih)-1978 berperihalkan pembakaran sisa, dan Indeks Pencemaran Udara digunakan sisa dan sebaliknya.

Dalam kesemua rawatan, didapati kandurgan P dan Mg adalah paling tinggi pada bahagian buah, diikuti oleh daun, batang, " crown", "peduncle" dan akar. Kandungan unsur K didapati mengurang mengikut urutan : buah, daun, batang, "peduncle", "crown" dan akar. Untuk unsur Ca, kandungan didapati mengurang mengikut urutan : daun, batang, buah, "crown", "peduncle" dan akar untuk rawatan i dan ii manakala kandungan mengurang mengikut urutan : batang, daun, buah, "crown", "peduncle" dan akar bagi rawatan iii dan iv. Akibat kedapatan nutrien yang rendah, penambahan abu sebanyak 1 – 31 kg/ha meningkatkan pengambilan P, K, Ca dan Mg serta hasil tanaman pada tahap bererti. Perbezaan kecekapan P hasil dari pembakaran sisa nenas (51 – 60 %) dan sebaliknya (53 – 21 %) di bawah keadaan pembajaan tidak ketara, manakala kecekapan K hasil dari pembakaran sisa melebihi sebanyak 6 % berbanding dengan hasil dari pembuangan sisa di bawah keadaan pembajaan. Selain daripada keupayaan penampanan yang tinggi, keupayaan membekalkan P, K, Ca dan Mg menunjukkan korelasi bererti dengan P, K, Ca dan Mg berintensiti di bawah keadaan pembajaan berbanding dengan keadaan tiada pembajaan.

Pergerakan unsur-unsur P, K, Ca dan Mg dalam sistem pengeluaran nenas dikenalpasti terdiri daripada input (baja, abu dan presipitasi), kehilangan (buah, pembuangan sisa daun, larutresap dan "run off"), pengambilan dan pemulangan, dan retensi nutrien. Dari segi input, pembajaan menyumbangkan amaun P, K, dan Ca tertinggi melainkan Mg, dimana abu memberi sumbangan tertinggi pada keadaan pembakaran dan untuk presipitasi di bawah keadaan tiada pembakaran. Larutresap merupakan punca utama kehilangan unsur-unsur P, K, Ca dan Mg untuk kedua-dua keadaan yakni pembakaran dan tiada pembakaran akibat dari kadar pembajaan tinggi dan taburan hujan tinggi. Unsur-unsur P, K, Ca dan Mg merekodkan keseimbangan positif pada penghujung penanaman di bawah keadaan pembakaran sisa manakala di bawah keadaan tiada pembakaran, kesemua unsur kecuali Mg turut merekodkan keseimbangan positif.

Keuntungan kasar daripada pengeluaran nenas di bawah keadaan pembakaran didapati meningkat sebanyak RM 90.00/ha hasil penambahan abu sebanyak 1.31 kg/ha. Pencemaran dan persiapan tanah (pembakaran atau sebaliknya) merupakan penyumbang utama kepada perbezaan dalam jumlah kos pengeluaran dan faedah penambahan bersih secara keseluruhan untuk amalan pembakaran sisa dan sebaliknya. Pembakaran adalah "viable" dari segi ekonomik sekiranya denda yang dikenakan adalah RM 10,000.00 tetapi dengan denda masakini sebanyak RM 500,000.00, amalan pembakaran adalah tidak "viable".

# CHAPTER I

# INTRODUCTION

Peat is generally less fertile, poorly drained and extremely acidic (Harun, 1992; Kanapathy, 1975). Among the studies meant to alleviate and improve upon these problems were the variation of soil moisture and nutrients release (Kanapathy, 1975), crop responses to liming (Ahmad et al., 1990), lime requirement determination of tropical peat (Husni et al., 1994) and nutrients capacity and intensity of tropical peat (Funakawa et al., 1996). As a result, there is lack of information about how nutrients released from various sources into the soil ecosystem take part in the nutrient cycle for specific crops planted on peat particularly pineapple.

The common practice in pineapple cultivation is burning the crop residue before planting followed by excessive fertilization. There has been little research on the quantification of nutrients released from burnt and unburnt residue, the quantity of nutrients lost, the amount retained in the soil and the amount recycled. The synthesis of this information may lead to the development of conceptual a model of nutrients uptake, cycling and accounting. This may not only contribute to the reduction of the polluting effect excessive fertilization on the environment but may also serve as a tool that can be used in maximizing the utilization of nutrients from fertilizers, ash and precipitation.

The greater awareness about the environmental pollution and the need for the attainment of sustainable agriculture and development also calls for the comparison of the economic values of the burnt and unburnt pineapple residue practices. This is necessary for the justification of the burnt and unburnt pineapple residue management practices.

The objectives of this study were: (1) To quantify the dry matter production and nutrients uptake under burnt and unburnt pineapple residue management practices, (ii) To explore the nutrients capacity and intensity of tropical peat under pineapple cultivation, (iii) To quantify the movement of nutrients in pineapple production system, and (iv) To conduct economic valuation of the burnt and unburnt pineapple residue management practices.

# CHAPTER II

# REVIEW OF LITERATURE

## Overview of Nutrient Cycling

Nutrient cycle describes the transformation of nutrients from one to another and accounts for the various ways in which a nutrient is added or lost from the soil (FAO, 1984). The focal point of the nutrient cycle is the soil phase, which serves as a pool, reservoir or sink of nutrients. Nutrient cycling in plants starts from the plant roots. Plant roots absorb nutrients from the soil which are then distributed among leaves, stem and roots. These nutrients are returned to the soil either directly by exudation or indirectly through leaf litter and root litter to complete the cycle (Breemen, 1995).

The next step involves nutrient mineralization from decomposing soil organic matter, which is made up of microbial biomass and more or less humified material. At any one time, only a very small fraction of nutrients present in an ecosystem is in the soil solution. The major part being stored in living and dead biomass, and reversibly bound to the organic plus inorganic exchange complex (Breemen, 1995).

The other sources that contribute or increase the nutrient pool is either through the application of fertilizers, precipitation, atmospheric dust (Mohamad, 1981) or through other means like weathering of primary minearals and lateral supply from the ground water (Breemen, 1995). The nutrients in the soil are usually decreased or entirely lost from the soil phase through leaching (Funakawa et al., 1996), crop removal (Coale et al., 1993; Py et al., 1987) and through other channels like surface or subsurface runoff (Verchot et al., 1997) and drainage (Duxbury and Peverly, 1978). Before proceeding with the discussion of the individual sources of nutrient addition and removal, a brief outline of the status and the dynamics of soil nutrients are highlighted.

## Status and the Dynamics of Nutrients in Soil

Nutrient elements in the soil exist in two forms-organic and inorganic. Those in the organic form are primarily in the humus and the organic matter layer of the soil, which are continuously decomposed by soil microbes. These nutrients get accumulated in mineral forms when biological immobilization is less active than mineralization. The soil organic matter is the result of the earlier biological decomposition of soil litter made of dead roots, leaves and stalks. The implication is that, besides those nutrients added to soil through man, quite a large amount of nutrients exist in the soil in organic forms, either as organic compounds at different levels of decomposition or part of the living soil organisms.

In the case of the inorganic nutrients, they are continuously formed either by mineralization of organic matter or from the weathering of soil minerals. These nutrients are largely retained on the soil colloids or in soil solution. Because of the absence of mineral matter in peatland, ion exchange and accretion in biomass are the major internal processes governing cation accumulation (Urban et al., 1995). While some of the inorganic nutrient elements may be absorbed by the roots and immobilized in the parts, some combine with certain ions to form insoluble complex unavailable to plants. Furthermore, some may be lost through leaching, drainage, erosion, or incorporated into microbial cell substances.

## Nutrient Additions to Soil

### Crop Residue Addition

As nutrients are being taken up and accumulated in plants, they are also returned to the soil as dead roots, leaves, stem and branches. Information on the amount of nutrients recycled from residue from pineapple planted on peat especially in Malaysia is still lacking. However it should be mentioned that studies have shown that there is usually a correlation between the tonnage of pineapple fruits harvested and the size of the plant (Py et al., 1987). Consequently, it is believed that the amounts of nutrients removed are in proportion to the amounts immobilized and that can be returned to the soil after destruction of the mother plants. These amounts are also proportionally affected by fertilization because fertilization improves growth and yield and thus increases the amount of organic matter and mineral elements that can be recycled.

It is worth noting that the plant utilizes not all the nutrients released from the recycled crop residue. At any point in time, the plant may use only certain amount of what is returned. The reason being that the proportion of nutrients used depends on the climate (rainfall in particular), soil type and the form crop residue is returned (burning, mulching or incorporated) in the soil (Ball-Coelho et al., 1993). There is significant lost of P and K added to peat during heavy rainfall (Funakawa et al., 1996).

**Precipitation**

It is well established that some plant nutrients contained in rainwater can contribute to the nutrient supply of crops. The amount contributed may partly depend on the quantity, size of storm and the location of rainfall (Veneklass, 1990; Verry and Timmons, 1977; Lag, 1968). The intensive investigation into the plant nutrient content of the precipitation from 12 different sites in Norway indicated that sites characterized by low rainfall tend to have very low amount of plant nutrients than those with high rainfall. Decrease in $Mg^{2+}$ and $SO_4^{2-}$ from the coastal districts to the interior was also observed. In the tropics, with annual rainfall of 2540 mm, approximately 0.2, 10.0, and 3.0 kg P, K, and Mg respectively may be added to a hectare of soil (Mohamad, 1981).