



UNIVERSITI PUTRA MALAYSIA

**TOWARDS SUSTAINABLE MANAGEMENT OF PINEAPPLE
RESIDUES**

OSUMANU HARUNA AHMED

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**DOCTOR OF PHILOSOPHY
UNIVERSITI PUTRA MALAYSIA**



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By

OSUMANU HARUNA AHMED

**Thesis Submitted to the School of Graduate Studies, Universiti Putra
Malaysia, in Fulfilment of the Requirement for the Degree of Doctor of
Philosophy**

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DEDICATION

This work is dedicated to the needy and the sincere helpers of the needy.



Abstract of the thesis submitted to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

TOWARDS SUSTAINABLE MANAGEMENT OF PINEAPPLE RESIDUES

By

OSUMANU HARUNA AHMED

Chairman: Ahmad Husni Mohd. Hanif, Ph.D.

Faculty: Agriculture

Studies were conducted to: (i) Investigate the effect of the modification of the existing N, P, and K programme and residue management practice on pineapple fruit yield, (ii) Compare the economic viability of in situ decomposition of pineapple residues untouched (IDPR), i.e. stacking of pineapple residue (leaves, crowns, and peduncles) slashed and raked from 0.60 m x 10 m rows into 0.90 m x 10 m rows (ZBT-zero burn technique), and in situ burning pineapple residues (IBPR) (iii) Quantify the amount of humic acid (HA) that could be extracted from composted pineapple leaves using 0.10M potassium hydroxide (KOH) produced from pineapple leaves and that of analytical grade (0.10M KOH), (iv) Compare the elemental composition (C, H, N, O, and S), functional groups (carboxylic, phenolic OH, and total acidity), and spectral characteristics of HA extracted from composted pineapple leaves using KOH from pineapple leaves and that of analytical grade, and (v) Investigate the potential value added agricultural products that could be produced from pineapple leaves.



The fertiliser programmes studied were: (i) Application of N (176, 176, 176, and 176 kg ha⁻¹), P (11, 11, 7, and 7 kg ha⁻¹), and K (89, 89, 188, and 188 kg ha⁻¹) fertilisers at 65, 135, 191, and 233 days after planting (DAP) (FP1), respectively (the usual practice); (ii) Application of N (176, 176, and 176 kg ha⁻¹), P (11, 11, and 7 kg ha⁻¹) and K (89, 89, and 188 kg ha⁻¹) fertilisers at 65, 135, and 191 DAP (FP2), respectively, and (iii) Application of N (176, 264, and 264 kg ha⁻¹), P (11, 14, and 11 kg ha⁻¹) and K (89, 183, and 285 kg ha⁻¹) fertilisers at 65, 135, and 191 DAP (FP3), respectively. The performances of these rates were studied under IDPR, ZBT, and IBPR (the usual practice).

In situ decomposition of pineapple residues without any interference (IDPR), ZBT, or IBPR did not improve fruit yield in the first rotation of the pineapple planting. Fruits yields of FP1, FP2, and FP3 under each of IDPR, ZBT, and IBPR were not statistically different. Application of N, P and K fertilisers at 65, 135 and 191 DAP (FP2) can serve as a competitive alternative to PF1 (existing fertilisation programme) as besides the fact that N, P, and K uptake and the yields of the two programmes were not statistically different, it was possible to save as much as US\$ 110.17 ha⁻¹ under FP2 through a reduction of N, P, and K fertilisers by 176, 7, and 188 kg ha⁻¹, respectively.

Taking into account the cost of environmental pollution associated with burning of pineapple residues, net present value (NPV) analysis revealed that either the IDPR

or the ZBT practices can serve as an economically competitive alternative to IBPR.

Potassium hydroxide (0.10M) from pineapple leaves extracted 20% HA from composted pineapple leaves while that of analytical grade (0.10M KOH) extracted 30%. However, the elemental composition (C, H, N, O, and S), the functional groups (carboxylic, phenolic OH, and total acidity), and the spectra characteristics of the HA extracted using these extractants were generally similar. Potassium hydroxide from pineapple leaves can therefore be used to extract some reasonable amount of HA without appreciably altering the elemental and functional groups constitution as well as the spectral characteristics of this humic substance. The potential of using KOH from pineapple leaves in humic substances extraction therefore looks promising. Useful products such as K-humate, and K-fulvate were also produced from pineapple leaves.



Abstrak tesis yang di kemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi syarat untuk mendapatkan ijazah Doktor Falsafah

KE ARAH PENGURUSAN LESTARI SISA NENAS

Oleh

OSUMANU HARUNA AHMED

Pengerusi: Ahmad Husni Mohd. Hanif, Ph.D.

Fakulti: Pertanian

Kajian telah di jalankan untuk: (i) Mengkaji kesan perubahan kepada pengubahsuaian program pembajaan N, P, K dan kaedah pengurusan sisa terhadap penghasilan buah nenas, (ii) Membandingkan viabiliti ekonomi penguraian sisa nenas secara in situ tanpa di ganggu (IDPR), iaitu menindan sisa nenas (daun, 'crown' dan tangkai), di potong dan dikumpul daripada baris 0.6 m x 10 m kepada 0.9 m x 10 m (ZBT-teknik pembakaran sifar), dan pembakaran sisa nenas secara in situ (IBPR), (iii) Menentukan kuantiti asid humik (HA) yang boleh di ekstrak daripada daun nenas yang di kompos menggunakan 0.10M kalium hidroksida (KOH) yang di hasilkan daripada daun nenas dan daripada gred analitik (0.10M KOH), (iv) Membandingkan komposisi elemen (C, H, N, O, dan S), kumpulan berfungsi (karboksilik, OH fenolik dan jumlah keasidan), dan ciri-ciri spektral HA yang di ekstrak daripada daun nenas yang di kompos dan daripada gred analitik, dan (v) Mengkaji potensi produk pertanian yang di tambah nilainya yang dapat di hasilkan daripada sisa daun nenas.



Program pembajaan yang digunakan adalah: (i) Pembajaan N (176, 176, 176, dan 176 kg ha⁻¹), P (11, 11, 7, dan 7 kg ha⁻¹), dan K (89, 89, 188, dan 188 kg ha⁻¹) pada 65, 135, 191, dan 233 hari selepas penanaman (FP1), (amalan biasa), (ii) pembajaan N (176, 176, dan 176 kg ha⁻¹), P (11, 11, dan 7 kg ha⁻¹), dan K (89, 89, dan 188 kg ha⁻¹) pada 65, 135, dan 191 hari selepas tanam (FP2), dan (iii) Pembajaan N (176, 264, dan 264 kg ha⁻¹), P (11, 14, dan 11 kg ha⁻¹) dan K (89, 183, dan 285 kg ha⁻¹) pada 65, 135, dan 191 hari selepas tanam (FP3). Kesan pembajaan ini di kaji, di bawah IDPR, ZBT, dan IBPR (amalan biasa).

Penguraian secara in situ sisa nenas tanpa sebarang gangguan (IDPR), ZBT atau IBPR tidak menambahkan hasil nenas pada pusingan pertama tanaman. Hasil buah untuk FP1, FP2, dan FP3 di bawah IDPR, ZBT, dan IBPR tidak berbeza secara statistik. Pembajaan N, P, dan K pada 65, 135, dan 191 hari selepas tanam (FP2) boleh menjadi suatu saingan alternatif kepada FP2 (amalan pembajaan biasa) selain daripada bukti bahawa pengambilan N, P, dan K dan hasil daripada kedua-kedua program pembajaan tidak berbeza secara statistik. Ia berkemungkinan memberi penjimatan sebanyak US\$ 110.17 di bawah FP2 melalui pengurangan baja N, P, dan K masing-masing sebanyak 176, 7, dan 188 kg ha⁻¹.

Dengan mengambil kira kos pencemaran alam sekitar yang berkaitan dengan pembakaran sisa nenas, analisis nilai kini bersih telah menunjukkan bahawa amalan IDPR atau ZBT boleh menjadi satu saingan secara alternatif kepada IBPR.

Kalium hidroksida (0.10M KOH) daripada sisa daun nenas telah mengestrak 20% HA daripada sisa daun nenas yang di kompos manakala kalium hidroksida daripada gred analitik (0.10M KOH) telah mengekstrak 30%, tetapi, komposisi elemen (C, H, N, O, dan S), kumpulan berfungsi (karboksilik, OH fenolik dan jumlah keasidan), dan ciri-ciri spektra adalah sama secara amnya. Kalium hidroksida daripada daun nenas boleh di gunakan untuk mengekstrak jumlah HA tanpa mengubah kandungan elemen dan kumpulan berfungsi serta ciri-ciri bahan humik. Ini memberikan suatu pandangan yang merangsangkan. Produk berguna seperti K-humate, dan K-fulvate juga dapat di hasilkan daripada sisa daun nenas.



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I certify that an Examination Committee met on 9th April 2002 to conduct the final examination of Osumanu Haruna Ahmed on his Doctor of Philosophy thesis entitled “Towards Sustainable Management of Pineapple Residues” in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

Ahmad Husni bin Mohd. Hanif, Ph.D.
Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Chairman)

Anuar Abd. Rahim Ph.D.
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

Mohd Hanafi bin Musa, Ph.D.
Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

Mohamed Selamat Madom, Ph.D.
Fruit Research Division
Malaysian Agricultural Research and Development Institute
Kluang, Johore
(Independent Examiner)



SHAMSHER MOHAMAD RAMADILI, Ph.D.
Professor/Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 03 JUN 2002

This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy.




AINI IDERIS, Ph.D.
Professor/Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: **08** AUG 2002

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.



OSUMANU HARUNA AHMED

Date: 3/06/02

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CHAPTER I

INTRODUCTION

Pineapple (*Ananas comosus*), a tropical fruit crop (Sampson, 1980) is commonly grown on mineral soils (Py et al., 1987) but in Malaysia, the crop is largely (17,000 hectare), and uniquely cultivated on peat (AGRIQUEST, 1999/2000). This practice has been in existence for nearly a century (Selamat and Ramlah, 1993). The present large scale cultivation started on small scale basis with no fertilisation but after the extensive and comprehensive survey of pineapple cultivation on peat in Malaysia (Dunsmore, 1957), the need to apply balanced fertilisers for a better growth and production of pineapple was apparent. Afterwards, some recommendations (Tay, 1972; Tay, 1973) were put forward. Probably when it became obvious that the existing recommendations have outlived their usefulness, new recommendations were issued (Selamat and Ramlah, 1993; Razzaque, 1999). Despite the fact that pineapple residue management practices such as burning, incorporation, mulching, or zero-burn, each of which, in one way or other forms an integral part of pineapple cultivation, none of the preceding studies took due cognisance of the performances of the fertiliser regimes under any of these residues management practices.

A recent study on the P, K, Ca, and Mg budget in pineapple cultivation has revealed that the existing fertiliser regime (successive applications of N, P, and K fertilisers at 65, 135, 191, and 233 days after planting (DAP)) is inappropriate (Ahmed et al., 2000). This observation has been ascribed to the lack of efficient synchrony between the release of these nutrients from the applied fertilisers (particularly the last stage of fertilisation, 233 DAP) and their uptake. At this period, nutrients are applied at a stage in pineapple growth when active nutrients uptake is quite slow (Py et al., 1987), and hence substantial amounts of nutrients get accumulated. But with average monthly rainfall of 159.75 mm coupled with the low clay in organic soils (Stevenson, 1994), high loss of P and K has been observed (Ahmed et al., 2000; Funakawa et al., 1996). For instance, 32% of P from China phosphate rock and 25.74% of K from muriate of potash of the total amount applied are lost through leaching. In terms of accumulation, 13.89% of P and 47.78% of K, respectively are retained in the soil. The high accumulation of K should be of utmost concern because it seems that there is no guarantee that the residual K can be of any significant benefit in the succeeding cropping years. Studies have shown that even though applied fertiliser K remaining in the exchangeable and solution forms are easily leached under high rainfall, residual K in organic soils is much affected (Shickluna et al., 1972).

From the foregoing nutrient leaching and accumulation estimations, it can be estimated that 46.79% (leaching plus accumulation) of P and as much as 73.52% (leaching plus accumulation) of K are not utilized. This estimation is consistent



with the findings of Ahmed et al. (1999) on P and K fertilisers' use efficiencies that were found to be 53.21 and 29.91%, respectively. At economic rate of 750 to 872 kg N ha⁻¹, Razzaque (1999) reported about 53.30 to 65.90% and 15 to 16% of N leaching and maximum recovery, respectively.

In spite of the growing concern of the polluting effects of excess fertiliser application on the environment, Malaysia is one of the heaviest users of fertilisers in the world (on unit land area basis) even though most of the fertilisers used in the country are imported. For 1995/96, Malaysia used 223.40 kg ha⁻¹ fertiliser nutrients, compared with a world wide use of only 83.40 kg ha⁻¹ (AGRIQUEST, 1999/2000). It is even thought that Malaysia is the only country in the world with a K requirement higher than N requirement. In 1998 (January to September), the fertiliser import bills for nitrogenous, phosphatic, and potassic fertilisers stood at 106.00 (RM 402.80), 39.39 (RM 149.68), and US\$ 115.58 (RM 439.20) million, respectively (AGRIQUEST, 1999/2000).

For the Malaysian pineapple industry to contribute to the reduction of these alarming bills there is a need to judiciously modify the present fertiliser regime. The modification however needs to be in tandem with a superior mode of handling pineapple residues like the modified version of zero-burn technique where with the exception of leaves that need to be removed for value addition instead of burning, roots, stems, crowns, and peduncles could be left to decompose in situ. This