UNIVERSITI PUTRA MALAYSIA

EFFECT OF COFEE RESIDUE AND CROPPING SYSTEM ON CROP YIELD AND PHYSICOCHEMICAL PROPERTIES OF THE SOIL IN SOUTHERN ETHIOPIA

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By

TENAW WORKAYEHU

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

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Dedication

This manuscript is dedicated to my beloved parents Ato Workayehu Kassa and W/o Asmaretch Leyew and to the late parents in law Ato Demissie Adera and W/o Yitemwork Aytenfsu, and my brothers and sisters

It is also dedicated to my dearest wife in life Tenagne Demissie and the three children we are proud of Henoke Tenaw, Beniam Tenaw and Ermias Tenaw.

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

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January 2006

Chairman: Associate Professor Ahmad Husni Mohd. Hanif, PhD

Faculty : Agriculture

Dumping and burning of coffee residue brought a serious environmental problem. On the other hand, low soil fertility due to multiple cropping with low input coupled with moisture stress results in decline in production. This study was conducted to evaluate decomposition and mineralization of N from coffee residue, and its effect on soil physicochemical properties, crop yield, and apparent nutrient balance. Decomposition and release of N in soil was studied using five periods of incubation (0, 30, 60, 90, and 120 days) and four rates of residue (0, 3, 6, and 9 Mg ha^{-1}) in pot experiment. The same rates of residue and four rates of N fertilizer (0, 30, 60, and 90 kg ha^{-1}), urea as source, were studied under field condition.

In the pot experiment, coffee residue decomposed in two phases: viz. an initial faster phase, and a later slow rate of decay. Decomposition rate (KD) was controlled by lignin (L) and nitrogen (N) contents, and L/N ratio (R^2 = 0.975**, n = 36). Immobilization of

soil N persisted for the entire 120 days, and release of N was controlled by lignin and cellulose contents, residue N and L/N ratio ($R^2 = 0.982^{**}$).

In the field, coffee residue alone significantly increased the mean uptake of N (106%), P (165%), and K (93%) in both maize and haricot bean, and its combination with N fertilizer enhanced the uptake by 143, 172 and 102%, respectively, compared to the control (without both residue and N fertilizer). Water use efficiency (WUE) increased significantly by 78% for maize and land equivalent ratio (LER) by 7% using coffee residue alone; and by 95% for total WUE and 16% for LER using residue along with N fertilizer. Efficiency of intercrop was 13% higher than sole cropping. Grain yield of maize with residue only varied between 52 and 88% of the sole maize yield (4,330 kg ha^{-1}).

In both pot and field experiments, soil amended with coffee residue showed increase in moisture content, total N (TN) and OC content. In the field study, the residue increased the physicochemical properties of the soil such as moisture (38%), TN (7.6%), and OC (8%) compared to the control. Intercropping increased soil moisture (3%), available P (8%) and K (15%) but reduced soil N (19%) and OC (4%) relative to the contents in sole maize.

Depletion of 20 and 70 kg N ha^{-1} was obtained in soil treated with coffee residue and N fertilizer alone, respectively. On the other hand, a positive balance of 19.4 kg N ha^{-1} was obtained from application of coffee residue followed by N fertilizer. The loss of K was high at 289 kg ha^{-1} with coffee residue only and at 159 kg ha^{-1} from coffee residue followed by N fertilizer. Application of 9 Mg ha^{-1} coffee residue and 9 Mg ha^{-1} coffee

residue with 90 kg N ha^{-1} gave the highest maize grain yields (3,807 and 4,133 kg ha^{-1}, respectively) and monetary values of 1,834 and 2,367 birr ha^{-1} (1USD= 8.40 Ethiopian birr), respectively, indicating the economic using coffee residues.

Amelioration of soil with coffee residue and/or N fertilizer provided improvement in soil physicochemical properties and crop yields. Therefore, utilization of coffee residue would not only provide an alternative source of plant nutrients but also alleviates soil fertility and reduce environmental pollution problems.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai mememuhi keperluan untuk ijazah Doktor Falsafah

KESAN SISA KOPI DAN SYSTEM PENANAMAN KEATAS HASIL TANAMAN DAN SIFAT-SIFAT FIZIK-KIMIA TANAH DI ETHIOPIA SELATAN

Oleh

TENAW WORKAYEHU

January 2006

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

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Pembuangan dan pembakaran sisa kopi membawa masalah persekitaran yang teruk. Disebaliknya, kesuburan tanah yang rendah akibat daripada penanaman berulang dengan input rendah bersama dengan tegasan kelembapan mengakibatkan pengurangan hasil pengeluaran. Kajian ini dijalankan untuk menilai penguraian dan pemineralan N dalam sisa kopi dan kesannya ke atas sifat-sifat fizik-kimia tanah, hasil tanaman dan imbangan nutrient nyata.

Penguraian dan pembebasan N dalam tanah dikaji menggunakan lima tempoh pemeraman (0, 30, 60, 90 dan 120 hari) dan empat kadar sisa kopi (0, 3, 6, dan 9 Mg ha^{-1}) di dalam pasu. Kadar sisa yang sama dan empat kadar baja N (0, 30, 60, dan 90 kg ha^{-1}), dalam bentuk urea, dikaji di ladang. Kajian di dalam pasu menunjukkan sisa kopi mengurai dalam dua fasa, melalui fasa awalan yang cepat dan berakli dengan pengakhiran, pada kadar berkunagan dan perlahan. Kadar penguraian (KD) dikawal oleh kandungan lignin (L) dan nitrogen (N), dan nisbah L/N (R^2 = 0.975**, n=36).

Immobilisasi N tanah berlaku selama tempoh 120 hari, dan pembebasan N dikawal oleh kandungan lignin ($R^2 = 0.982^{**}$) dan nisbah L/N.

Kajian di ladang menunjukan pemberian sisa kopi mengakibatkan peningkatan paras N (106%), P (165%), dan K (93%) untuk kedua-dua jagung dan kacang harikot, dan kombinasi dengan baja N menguatkan lagi pengambilan N masing-masing kepada 143, 172, dan 102% berbanding dengan kawalan (tanpa sisa kopi dan baja N). Kecekapan penggunaan air (WUE) meningkat dengan bererti sebanyak 78% untuk jagung dan nisbah setara tanah (LER) sebanyak 7% dengan menggunakan sisa kopi sahaja dan sebanyak 95% untuk jumlah WUE dan 16% LER dengan menggunakan sisa kopi bersama baja N. Kecekapan tanaman berselang (jagung dengan kacang harikot) adalah 13% lebih tinggi jika dibandingkan dengan tanaman tunggal. Hasil bijirin tanaman jagung dirawat dengan sisa kopi berada diantara 52 dan 88% daripada hasil tanaman jagung tunggal (4,330 kg ha^{-1}). Dalam kedua-dua kajian berpasu dan ladang, tanah yang ditambah dengan sisa kopi menunjukkan pertambahan kandungan kelembapan, jumlah N (TN) dan kandungan karban organik (OC).

Di ladang, penambahan sisa meningkatkan sifat kimia-fizik tanah, seperti kelembapan (38%), TN (7.6%) dan OC (8%) berbanding dengan kawalan. Tanaman berselang meningkatkan kelembapan tanah (3%), kedapatan P (8%) dan K (15%) tetapi menurunkan kandungan N tanah (19%) dan OC (4%) berbanding dengan kandungan yang ditanam jagung tunggal. Pengurangan sebanyak 20 dan 70 kg ha^{-1} N didapati dari tanah masing-masing dirawat dengan sisa kopi dan baja N sahaja. Disebaliknya imbangan positif sebanyak 19.4 kg N ha^{-1} diperolehi daripada penambahan sisa kopi

yang diikuti baja N. Kehilangan K yang tinggi sebanyak 289 kg ha^{-1} dengan sisa kopi sahaja dan 159 kg ha^{-1} dengan sisa kopi yang ditambah baja N. Penggunaan sisa kopi sebanyak 9 Mg ha^{-1} sahaja dan 9 Mg ha^{-1} sisa kopi yang diikuti dengan 90 kg N ha^{-1} menghasilkan bijirin jagung masing-masing 3,807 dan 4,133 kg ha^{-1} dan nilai kewangan 1,834 dan 2,367 birr ha^{-1}(1USD = 8.40 birr Ethiopia), menunjukkan kepentingan penggunaan sisa kopi dan baja N.

Penambahbaikan tanah dengan sisa kopi dan baja N meningkatkan sifat fizik-kimia tanah dan penghasilan tanaman. Oleh itu, penggunaan sisa kopi bukan sahaja membekalkan sumber nutrien tanaman alternatif tetapi juga sebagai pembaik kesuburan tanah dan mengurangkan masalah pesekitaran jika sisa ini dibuang.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

BOPED	Bureau of Planning and Economic Development
SNNNRS/UNECA	Southern Nation Nationalities and Regional State//United Nations Economic Commission for Africa
FAO	Food and Agricultural Organization of the United Nations
CTA	Coffee and Tea Development
CSA	Central Statistics Authority
MOA	Ministry of Agriculture
DAP	Diammonium Phosphate
KD	Decomposition Rate Constant
LER	Land Equivalent Ratio
CR	Competitive Ratio
WUE	Water use Efficiency
TWUE	Total Water Use Efficiency
CIMMYT	International Wheat and Maize Research Organization, Mexico
CIAT	International Research Institute for Tropical Pulses
ICARDA	International Centre for Agricultural Research for Dry Land Agriculture
LAI	Leaf Area Index
AARC	Awassa Agricultural Research Centre
MA	Monetary Advantage
USDA	United States Department of Agriculture