



UNIVERSITI PUTRA MALAYSIA

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

TENAW WORKAYEHU.

FP 2005 5

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**DOCTOR OF PHILOSOPHY
UNIVERSITI PUTRA MALAYSIA**

2006



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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**

January 2006



Dedication

This manuscript is dedicated to my beloved parents Ato Workayehu Kassa and W/o Asmarech 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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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 memenuhi keperluan untuk ijazah Doktor Falsafah

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

Oleh

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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 imbalan 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 menunjukkan 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 ($4,330 \text{ kg ha}^{-1}$). Dalam kedua-dua kajian berpasu dan ladang, tanah yang ditambah dengan sisa kopi menunjukkan pertambahan kandungan kelembapan, jumlah N (TN) dan kandungan karbon 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 imbalan positif sebanyak $19.4 \text{ kg N ha}^{-1}$ 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.

ACKNOWLEDGEMENTS

I would like to express my most sincere appreciation to Associate Professor Dr. Ahmad Husni Mohd Hanif, chairman of my supervisory committee, for his continuous and valuable guidance and advice, encouragement, and constructive criticism throughout my study and in the preparation of this manuscript. Not only this he also devoted his money and time while I was sick and his advice to care myself when I went back to my country, Ethiopia.

My sincere appreciation is also extended to Associate Professor Dr. Anuar Abdul Rahim as member of my supervisory committee for his commitment, valuable advice and devotion of his time during the preparation of this manuscript. I also do give my sincere appreciation and respect to Professor Dr. Zaharah Abdul Rahman, member of the supervisory committee, who devoted her time and commitment in advising and forwarding valuable suggestion during the preparation of this manuscript.

I would also like to give my due respect to Dr. Paulos Dubale, director for soil and water research at Ethiopian Agricultural Research Organization (EARO), for his valuable advice, and continuous support during the execution of my experiments back home.

I also extended my thanks to Associate Professor Dr. Siti Zauyah Darus for her devotion to accomplish my request during my study and for the visit she made when I was back home while she was on trip to Ethiopia. Sincere appreciation also goes to Associate

Professor Dr. Mohd Hanafi Musa for his valuable suggestion and translating the abstract to Bahasa Malayu.

My appreciation and thanks is also extended for the financial support afforded by the Government of Ethiopia, Ethiopian Agricultural Research Organization (EARO) and Agricultural Research and Training Project (ARTP) to pursue my tertiary education in Universiti Putra Malaysia.

My heartfelt thanks are extended to Dr. Osman, Dr. Prama, Dr. Jalloh, and Dr. Adrinal for their continuous support in particular Dr. Osman, Dr. Prama and Dr. Jalloh for their advice, support, and encouragement. I would like also to extend my appreciation to Dr. Kemal Ali for his financial support during the execution of my experiment back home, and Dr. Mohammed Daud for his advice and suggestion.

My appreciation is also extended to W/o Alemtsehay and other staffs of the National Soil Laboratory Research who helped me in laboratory work. My thanks are also forwarded to those who helped me during my field work at Awassa Research Center and the support they gave me.

Above all I would like my heartfelt admiration to my beloved wife W/o Tenagne Demissie for her understanding, continued support and encouragement, and sacrifices during the period of my study in Malaysia and to our sons Henoke Tenaw, Beniam Tenaw and Ermias Tenaw for their encouragement, support, pray and follow up through email wishing me all the success during my stay in Malaysia. I also wish them all the

success in their study now and in the future. My thanks and appreciation also goes to my father Ato Workayehu Kassa, mother W/o Asmaretech Leyew, the late parent in law Ato Demissie Adera and W/o Yitemwork Aytenfsu, my brothers Wondimeneh, Tsegaye, Temsegen, Hailemariam, and my sisters Tiruaynet and Askaletch.

I also wish to extend my thanks to Ato Dejene Demissie who dedicated his time and energy in following up and taking care of my family. I wish them all the best through their life and I pray to my God and Saint Mary for their stay in this world. Of all I thank my almighty God who has taken me, my parents and all my relatives to this date and gave us love, safety and peace.



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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

