



FUNCTION OF SOME ECOSYSTEM COMPONENTS AT NATURAL FOREST AND CACAO AGROFORESTRY SYSTEMS AT THE MARGIN OF LORE LINDU NATIONAL PARK, CENTRAL SULAWESI

BY:

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**DEPARTEMENT OF BIOLOGY
THE POST GRADUATE SCHOOL
BOGOR AGRICULTURAL UNIVERSITY
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ABSTRACT

TRIADIATI. **Function of Some Ecosystem Components at Natural Forest and Cacao Agroforestry Systems at the Margin of Lore Lindu National Park, Central Sulawesi.** Under direction of SUKISMAN TJITROSEMITO, EDI GUHARDJA, SUDARSONO, IBNUL QAYIM

Cacao agroforestry is a traditional form of agriculture practiced by the people of Central Sulawesi. These agroforestry systems vary from a simple system, following selective cutting of forest trees, to a more sophisticated planting design. The aims of this research were (1) to determine litterfall dynamics, leaf-litter decomposition, and fine root biomass, (2) to determine active fraction on soil macro-organic matter (SOM) in natural forest and cacao agroforestry systems, and (3) to assess nitrogen resorption and nitrogen use efficiency (N NUE) and implication for cacao establishment.

The field studies were conducted in three types of cacao agroforestry systems at the northeastern margin of Lore Lindu National Park (LLNP). Field study sites covering in natural forest (NF) and in three cacao agroforestry systems that is cacao was planted under remaining forest cover (CF1), under planted trees (CF2), and between shade trees *Gliricidia sepium* (CP). The parameters are nitrogen soil content, fine root biomass, soil macro-organic matter by size and density fractionation, soil surface organic layer by quadrant, litterfall production by litter trap, and rate of decomposition by litter bag, nitrogen use efficiency in cacao plant and ecosystem scale, and nitrogen resorption.

The results shown that the greatest litterfall production was recorded in the NF with the fastest rate of decomposition. Among cacao agroforestry systems, the CP produced the greatest litterfall, but the rate of decomposition was lower than that of the CF1. Leaf-litter was predominant litter component compared to the other components (woody litter and reproductive parts) in all study sites. The monthly litterfall in NF and cacao agroforestry systems were influenced by climate. The rate of leaf-litter decomposition was done in two periods, which revealed a different pattern. Fine roots biomass in the natural forest was higher than those of cacao agroforestry systems. Fractionation of soil macro-organic matter resulted three fractions with the order of total fractions as followed intermediate fraction (MF) > heavy fraction (HF) > light fraction/active fraction (LF). The percentage of LF in the natural forest was lower than those of in the cacao agroforestry systems. The carbon organic and nitrogen content in the LF in the natural forest was higher than those of cacao agroforestry systems. Among cacao agroforestry system, the organic carbon and nitrogen content in the LF was the highest in the CF2. The dry weight of LF-SOM was influenced by amount of litterfall and rate of decomposition. Nitrogen resorption and nitrogen use efficiency in cacao plant (N NUE_C) were not significantly different among three cacao agroforestry systems. Nitrogen use efficiency in four different ecosystems (N NUE_{Es}) showed that ecosystem CP was significantly lower than those the three ecosystems.

It can be concluded that land use change from natural forest to cacao agroforestry systems would influence ecosystem function. Cacao agroforestry system under CF1 and CF2 are able to maintain ecology performance and biodiversity similar to natural forest.

Key words: cacao agroforestry, litterfall, decomposition, soil macro-organic matter, nitrogen resorption, nitrogen use efficiency.

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ABSTRAK

TRIADIATI. Fungsi Beberapa Komponen Ekosistem di Hutan Alam dan Agroforestri Kakao pada Pinggir Batas Taman Nasional Lore Lindu, Sulawesi Tengah. Di bawah bimbingan SUKISMAN TJITROSEMITO, EDI GUHARDJA, SUDARSONO, IBNUL QAYIM

Komoditi kakao banyak ditanam di Sulawesi Tengah dalam sistem agroforestri dan merupakan perkebunan yang dikelola rakyat. Sistem agroforestri kakao yang ada beragam, dari bentuk penanaman diantara vegetasi hutan hingga ditanam dengan pola tanam yang seragam. Penelitian ini bertujuan (1) menentukan dinamika produksi serasah, menghitung laju dekomposisi dan dinamika *fine root*; (2) menentukan 'active fraction' dalam bahan makro-organik tanah di hutan alam dan agroforestry kakao; (3) menghitung resorpsi nitrogen pada tanaman kakao dan efisiensi penggunaan nitrogen.

Penelitian dilakukan berlokasi di sebelah barat tepi Taman Nasional Lore Lindu, Sulawesi Tengah. Empat tipe pemanfaatan lahan yang digunakan sebagai lokasi penelitian meliputi hutan alam (NF) dan tiga tipe sistem agroforestri kakao yaitu kakao ditanam di bawah vegetasi hutan (CF1), ditanam di bawah tanaman lokal (CF2) dan ditanam di bawah *Gliricidia sepium* (CP). Parameter yang diamati adalah kandungan N tanah, *fine root*, bahan makro-organik tanah (BOT) dengan metode *size and density fractionation*, lapisan bahan organik di atas tanah, produksi serasah dengan metoda jaring serasah, laju dekomposisi dengan metoda kantong serasah, efisiensi pemanfaatan nitrogen pada tanaman kakao ($N\ NUE_C$) dan skala ekosistem ($N\ NUE_{ES}$), dan resorpsi N.

Hasil penelitian menunjukkan bahwa dari empat tipe pemanfaatan lahan, NF menghasilkan serasah tertinggi dengan laju dekomposisi tercepat. Diantara agroforestri kakao, kakao yang ditanam di CP menghasilkan serasah terbanyak tetapi laju dekomposisinya lebih rendah dari pada kakao di lokasi CF1. Daun merupakan komponen serasah terbanyak dibanding komponen serasah lainnya. Produksi serasah perbulan berfluktuasi dan dipengaruhi oleh iklim setempat. Laju dekomposisi serasah daun yang dilakukan pada dua periode yang berbeda mempunyai pola yang berbeda pula. Berat kering biomassa *fine root* pada NF lebih tinggi daripada agroforestri kakao. Fraksionasi BOT diperoleh tiga fraksi dengan urutan berat kering yaitu fraksi sedang (MF) > fraksi berat (HF) > fraksi ringan/active fraction (LF). Persentase LF pada NF lebih rendah daripada agroforestri kakao. Karbon organik dan N pada LF di NF lebih tinggi dibanding pada agroforestri kakao. Di antara agroforestri kakao, CF2 mempunyai kandungan C-organik dan N tertinggi. Berat kering LF berkorelasi positif dengan produksi serasah dan laju dekomposisi. Resorpsi dan $N\ NUE_C$ tidak menunjukkan perbedaan yang signifikan pada ketiga agroforestri kakao. Tetapi $N\ NUE_{ES}$ pada empat ekosistem yang berbeda menunjukkan bahwa ekosistem CP mempunyai efisiensi lebih rendah dan berbeda secara signifikan dengan tiga ekosistem lainnya.

Disimpulkan bahwa perubahan pemanfaatan lahan dari hutan alam menjadi sistem agroforestri kakao akan mempengaruhi fungsi ekosistem. Agroforestri kakao pada CF1 dan CF2 merupakan tipe agroforestri yang layak untuk di pertahankan karena mempunyai kemiripan dengan hutan alam.

Kata kunci: agroforestri kakao, serasah pohon, dekomposisi, bahan makro-organik tanah, resorpsi nitrogen, efisiensi penggunaan nitrogen.

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SUMMARY

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Cacao agroforestry is a traditional form of agriculture by the people of Toro village, Central Sulawesi. These agroforestry systems vary from a simple system, by taking the system of selective cutting of forest trees, to a more sophisticated planting design.

The aims of this research were (1) to determine litterfall dynamics, leaf-litter decomposition, and fine root biomass in natural forest and cacao agroforestry systems; (2) to determine active fraction on soil macro-organic matter (SOM) and to know relation of litterfall as an input of organic matter in soil with SOM; (3) to assess nitrogen resorption and nitrogen use efficiency (N NUE). The field studies were conducted in three different types of cacao agroforestry systems at the northeastern margin of Lore Lindu National Park (LLNP), which is located in Central Sulawesi, Indonesia ca. 75 km southeast of Palu. The whole site is located at an elevation of 800 m to 1100 m in Toro village, Kulawi district, Central Sulawesi, Indonesia. The experiment began in March 2005 and ended in March 2006. Field study sites covering in natural forest (*wana*-NF as an undisturbed ecosystem) and in three cacao agroforestry systems were *pahawa pongko 1*-CF1, *pahawa pongko 2*-CF2; and *huma*-CP. Plot size was 30 m x 50 m in every study site. The topography of study sites varied with the different slope. Each plot was divided into 20 subplots, where soil, fine root, soil macro-organic matter, and soil surface organic layer samples were taken. Litterfall production was collected monthly intervals from 10 traps in each plot for one year. The rate of decomposition was evaluated by using the litter bag technique. The amount of soil macro-organic matter was analyzed by using size and density fractionation method. Fractions of soil macro-organic matter were fractionated in silica suspensions (LUDOX solution). Quality of soil macro-organic matter was determined with nitrogen, and organic carbon content.

The results shown that the greatest litterfall production was recorded in the natural forest ($1367.4 \text{ g m}^{-2} \text{ y}^{-1}$) with the fastest rate of decomposition ($k = 2.46$). Among cacao agroforestry systems, the cacao agroforestry under CP (*huma*) produced the greatest litterfall that was $822 \text{ g m}^{-2} \text{ y}^{-1}$, but the rate of decomposition was lower than that of the cacao agroforestry under CF1 (*pahawa pongko 1*). Leaf-litter was predominant litter component average ranged from 76.5 to 83.5% compared to the other components (woody litter and reproductive parts) in all study sites. The monthly litterfall in natural forest and cacao agroforestry systems were influenced by climate. The rate of leaf-litter decomposition of the natural forest and cacao agroforestry systems were done in two periods. The rate of decomposition was determined with the percentage of mass remaining in the end of the litter incubation. The rate of decomposition of leaf-litter from natural forest and cacao agroforestry systems since September until December showed a similar pattern, whereas those since March until June revealed a different pattern. Generally, the natural forest had the fastest rate of decomposition than those of cacao agroforestry systems. Based upon the content of nutrient (carbon and nitrogen) remaining in the litter, there was a release of carbon and nitrogen as decomposition proceeded in all

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study sites. The amount of carbon released in first period those under NF (1.08 g) and CP (1.05 g) did not differ significantly, but higher than CF1 (0.73 g) and CF2 (0.39 g). The amount of carbon released in second period under NF (0.49 g), CF2 (0.45 g) and CP (0.63 g) were similar and higher than CF1 (0.26 g). The nitrogen released in first period under NF (0.05 g) differed significantly and higher than CF1 (0.02 g), CF2 (0.02 g) and CP (0.03 g). The nitrogen released in second period was quite similar in NF (0.008 g) and cacao agroforestry systems (0.009 g, 0.009 g, 0.01 g respectively). Fine roots biomass dry weight in the natural forest was higher than those of cacao agroforestry systems and was influenced by amount of soil surface litter.

Fractionation of soil macro-organic matter with size and density fractionation method resulted three fractions with the order of total fractions as followed intermediate fraction (MF) > heavy fraction (HF) > light fraction (LF). The total soil macro-organic matter decreased with increasing of land use intensity. The carbon organic and nitrogen content in the LF in the natural forest was higher than those cacao agroforestry systems. Among cacao agroforestry system, the organic carbon and nitrogen content in the LF was the highest in the cacao agroforestry CF2 (*pahawa pongko 2*). The dry weight of LF-SOM was correlated by amount of litterfall and rate of decomposition.

Nutrient resorption is a process in which nutrients are withdrawn from leaf prior abscission and redeployed in developing tissues. The resorption of nutrients prior to abscission is one of the key process by which plants conserve. Nitrogen resorption and nitrogen use efficiency in cacao plant ($N\ NUE_C$) were not significantly different among three type cacao agroforestry. Nitrogen use efficiency in four different ecosystems ($N\ NUE_{Es}$) showed that ecosystem cacao agroforestry C (*huma*) was significantly lower than those the three ecosystems. Nitrogen use efficiency in ecosystem presented nitrogen sufficiency of land for plant growth.

It can be concluded that land use change from natural forest to cacao agroforestry systems would decrease the ecosystem function. Cacao agroforestry under CF1 and CF2 are able to maintain ecology performance and biodiversity similar to natural forest.

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TRIADIATI

**A dissertation submitted to fulfill one of the requirements for the
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Post Graduate School, Bogor Agricultural University,**

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FOREWORD

Many thanks to Allah SWT for blessing me to finish this dissertation “Function of Some Ecosystem Components at Natural Forest and Cacao Agroforestry Systems at the Margin of Lore Lindu National Park, Central Sulawesi”.

Chapter VI – Nitrogen Resorption and Nitrogen Use Efficiency in Cacao Agroforestry Systems Managed Differently in Central Sulawesi - was published in HAYATI Journal Biosciences (December 2007:127-132). A part of chapter IV and V were presented in Summer School Program in Göttingen, Germany (2005) and STORMA Stakeholder Workshop, Jakarta (2008).

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CURRICULUM VITAE

TRIADIATI was born on 24 February, 1960 in Surabaya (East Java), a third daughter from five children from father Sarlan Adisutjipto and mother Soetarwi. The Faculty of Biology, Gadjah Mada University in Yogyakarta, was institution she had chosen for study. She became a student in 1979 and graduated in 1984.

Since 1986 she worked at Diponegoro University, Semarang until 1998 as a lecturer. She attended a research Program in Center of Inter University at Bandung Technological Institute for one and a half year in 1988-1990. In 1991, she began to study in Agronomy Department, Post Graduate Program at Bogor Agricultural University. She graduated in Master of Sciences (MSi.) in 1994. Since 1998 she has been working at Biology Department, Bogor Agricultural University as a lecturer.

In 2003, she enrolled Bogor Agricultural Institute in the Biology Department for her doctorate program, which is funded by BPPS Scholarship from The Indonesian Government through The Directorate General of Higher Education, Department of National Education, Republic of Indonesia with research facilities from STORMA.

She has actively participated in several International and National symposiums, such as Summer School Program in Göttingen, Germany (2005) funded by DAAD (German Academic Exchange Service) and BMBF (Bundesministerium für Bildung und Forschung). In 2008, she participated in STORMA Stakeholder Workshop organized by Indonesian Institute of Sciences (LIPI) and STORMA.

She is married with Drs. Kusumoantono, MSi. and has two children namely Zaqni Ajikusumo and Tasya Nabilla Adiansari.

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Bogor Agricultural University

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