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Original research article

Fine Root Production and Decomposition in Lowland Rainforest and Oil Palm Plantations in Sumatra, Indonesia

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ABSTRACT

Transformation of tropical rainforest into oil palm plantation not only has impacts on biodiversity but also affects ecosystem functions such as production and decomposition of fine roots as a nutrient source for plant. The objective of the research was to evaluate the production and decomposition rate of fine roots in natural forest (NF) at Bukit 12 National Park and oil palm plantation (OP) in Jambi, Sumatra. The soil core and litter bag methods were used to obtain fine root production and decomposition data. The results showed that generally, there was the same pattern in fine root production between NF and OP. The annual fine root productivity was found to be higher in NF than that of OP. Rainfall in NF and air temperature in NF and OP were the most significant climate factors affecting fine root production. The remaining fine root biomass decreased as the incubation time increased. The decomposition rate constant (k value) was significantly higher in NF than in OP. Our data showed that the nutrient turn-over of NF fine roots was faster than of OP fine roots. Nitrogen, carbon content, and C/N ratio were the main factors that influenced fine root decomposition.

1. Introduction

Transformation of tropical rainforest into agricultural systems not only leads to massive losses in the biodiversity (Koh & Wilcove 2008) but also has major impacts on ecosystem function such as the availability of nitrogen. Fine roots play an important role in fulfilling the nutrient cycles of forest ecosystems (Santantonio & Hermann 1985) and are known as a prominent sink of canopy photosynthetic carbon (Nadelhoffer & Raich 1992). Roots provide pathways for carbon and energy movements from canopy to the soil, so the root production and root turnover directly affect the biogeochemical cycle of carbon (Koh & Wilcove 2008) and nitrogen (Nadelhoffer & Raich 1992). Although fine roots are individually very small (≤2 mm in diameter), in total, they can make up 30%–50% of the annual primary production (Ruess *et al.* 1996; Gill and Jackson 2000). The small diameter, short lifespan, and low C/N ratio of fine roots affect their turnover and decomposition rate (Hendrick & Pregitzer 1993). Fast growth and rapid turnover of fine roots become important factors in nutrient cycles including N cycle. Therefore transformation of forests to oil palm plantations (OPs) may affect the fine root system, turnover of nutrients, and nutrient cycling in the ecosystem (Silver *et al.* 2005).

Large areas of natural forest (NF) in Jambi have been converted into plantations and thus likely changed the nutrient cycles, including the fine root system and its contribution to the ecosystem. This conversion likely has impacts on the biomass and the distribution of fine roots, and their decomposition. The conversion of NFs into plantations could reduce fine root biomass, particularly in the uppermost soil layer (0–10 cm depth). A decrease in production and decomposition of fine roots, including a reduction in litter production above ground, will lead to the decline of soil organic matter and the presence of soil nutrients (Yang *et al.* 2004). Furthermore, biomass and fine root production are altered by disturbances, such as disturbance during selective logging and clear-felling of trees (Barbhuiya *et al.* 2012; Gautam and Mandal, 2012) and forest disturbance (Barbhuiya *et al.* 2012; Leuschner *et al.* 2006).

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One area of Jambi's tropical rainforest that has experienced large scale conversion is Bukit 12 National Park (TNBD). Formerly, TNBD was an area that consisted of permanent production forest, limited production forest, and forest for other uses. Currently, TNBD is dominated by secondary forest because of the conversion into plantations including OPs.

The importance of fine roots as a principal sink in TNBD needs to be considered, especially in the context of land use changes that interfere in the process of nutrient recycling and availability of plant nutrients. To predict the influence of land use change on the belowground ecosystem, especially on fine roots, a better understanding of production and decomposition processes of fine roots as well as the effects of environment factors and litter quality to those processes is required. Therefore the studies comparing the production and decomposition of fine roots between OP areas and NF are needed. This research objective was to determine and compare the production and decomposition of fine roots in OP and NF in TNBD, Jambi, Indonesia.

2. Materials and Methods

2.1. Time and place of the study

The study was conducted from September 2012 to September 2013 in Sarolangun, Jambi province. The TNBD is a relatively small national park that covers 605 km^2 in Jambi (Indonesia), which represents the lowland tropical rain forests in Jambi province. Only the northern part of this park consists of primary rainforest, whereas the rest is secondary forest, as a result of the previous logging activity. In the past, the forest area was designated as permanent production forest, limited production forest, and other forest land uses which were later merged to become a National Park.

The study site of this research was Bukit 12 National Park (TNBD) NF and OP with 7–10 in age, with the following specific plot location coordinates:

1. S 01°59′42.5″ E 102°45′08.1″ (NF1).
2. S 01°56′33.9″ E 102°34′52.7″ (NF2).
3. S 01°56′31.9′ E 102°34′50.3″ (NF3).
4. S 02°04′32.0″ E 102°47′30.7″ (OP1).
5. S 02°04′15.2″ E 102°47′30.6″ (OP2).
6. S 02°04′15.2″ E 102°47′30.6″ (OP3).

in Sarolangun district, Jambi (Figure 1). The soil at this experimental site is podsolic soil with the soil pH between 3 and 5. The average monthly rainfall was 291.08 mm while the highest and lowest precipitation occurred in December 2012 (529 mm) and June (33 mm) 2013, respectively. The average daily temperature varied from 26°C to 28°C. The daily precipitation and solar radiation ranged between 77% and 91% and 41.5% and 64.25%, respectively. Climate data were acquired from the *Badan Meteorologi Klimatologi dan Geofisika* Climatology Station of Jambi, at Jl. Raya Jambi-Muara Bulian Km 18, Simpang Sungai Duren, Jambi.

2.2. Fine root production

Fine root was sampled in NF and OP by collecting 20 soil cores (5 cm in diameter) at a depth of 20 cm at random from each observation plot every 3 months. Soil cores were cut into 20 cm

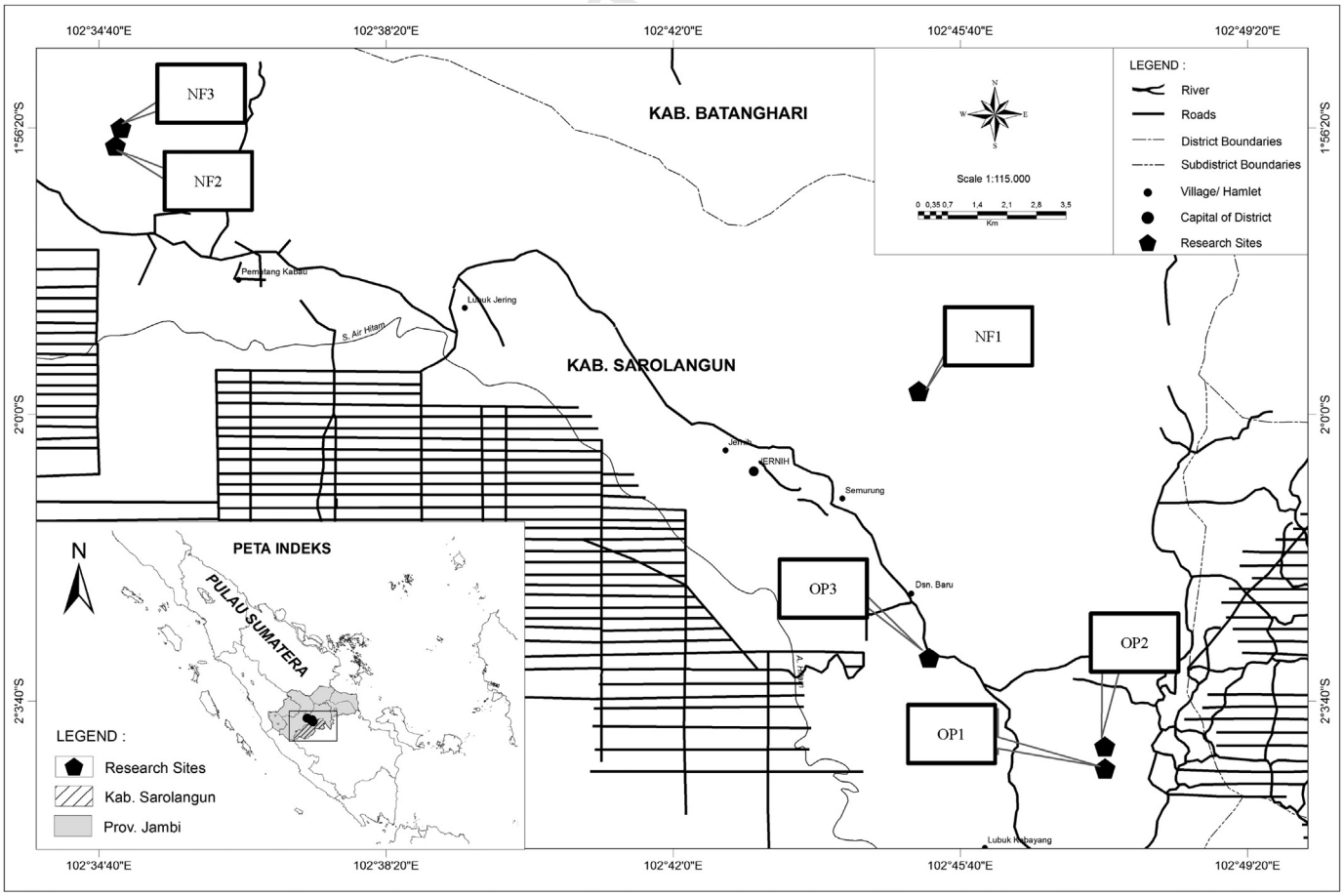

Figure 1. Map of study site of natural forest (NF; Bukit 12 National Park) and oil palm plantation (OP) at Jambi, Indonesia.

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