Litter production of logged-over forest using Indonesia selective cutting system and strip planting (TPTJ) at PT. Sari Bumi Kusuma

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Abstract

Enrichment is a planting activity in logged-over areas with less natural regeneration of commercial species. Enrichment planting on Indonesian Silvicultural System of Selective Cutting and Strip Planting (TPTJ) aims to increase the productivity of logged-over areas (LOA) using Strip Plantation System. Strip Planting System is an intensive management system attempted by opening logged-over area for strip planting and planting purpose species. Plantation in Strip Plantation System needs much nutrition for its growth. Nutrition returning through litter on TPTJ system was essentially notified. This research aims to identify litter production in strip planting and on-strip planting at logged-over areas, within one year, five years, ten years after logging, and primary forest at PT. Sari Bumi Kusuma. This research was conducted from September 2010 to February 2011. The litter trap was used to calculate litter accumulation. Litter production at LOA after one year of planting is 2.27 ton.ha\(^{-1}\).6 months\(^{-1}\) in strip planting and 3.68 ton.ha\(^{-1}\).6 months\(^{-1}\) in non-strip planting; litter production at LOA after five years is 4.97 ton.ha\(^{-1}\).6 months\(^{-1}\) in strip planting and 4.98 ton.ha\(^{-1}\).6 months\(^{-1}\) in non-strip planting; while litter production at LOA after ten years is 4.03 ton.ha\(^{-1}\).6 months\(^{-1}\) in strip planting and 4.67 ton.ha\(^{-1}\).6 months\(^{-1}\) in non-strip planting. Using Selective Cutting and Strip Planting System (TPTJ), it is found that litter production in strip planting was not significantly different from that in non-strip planting, and that the litter production is recovered after 5 years.

Keywords: forest; litterfall; strip planting; logged-over area; selective cutting

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1. Introduction

The lowland tropical rainforest in Indonesia is heterogeneous (high diversity of species and multi layers) dominated by Dipterocarpaceae family [1], whereas it is also recognized as carbon resource with an average above ground biomass of 457.1 ton.ha\(^{-1}\) [2]. High number of biomass in the lowland tropical rain forest is caused by high density of large canopy trees of Dipterocarpaceae whereas the basal area in the primary forest of lowland tropical forest was 12.64 ± 1.32 m\(^2\).ha\(^{-1}\) [3]. Based on characteristics of lowland tropical forest, silvicultural system is developed to manage forest using selective cutting and strip planting system (Tebang Pilih Tanam Jalur, TPTJ) in order to produce woods because Dipterocarpaceae woods are recognized for their good timber qualities, and they are marketed as plywood and saw timber [4]. They are imported to some counties such as Japan, Australia, European Union, South Korea, etc [5].

In brief, the TPTJ is attempted in harvesting cycle of 25 years by logging mature commercial species with diameter at breast height (DBH) of more than 40 cm, which are mostly Dipterocarpaceae species [6]. The selective cutting system is able to reduce the number of Dipterocarpaceae stock to 55-66% and significantly decrease the amount of carbon [7]. Thus, the recovery rate of carbon stock in the secondary forest is very slow, whereas the above ground recovery 35 years after cutting was 70% of original biomass Carbon [8]. On the other side, the soil is dominated by Ordo Ultisol, which is strongly weathered and is acidic due to the leaching and also infertile [9] whereas pH of H\(_2\)O and KCl are 3.97-4.50 and 3.57-4.07 [10], respectively. Thus, availability of litter is an essential point in maintaining balance of nutrient in forest and nutrient cycling pathway in these ecosystems [11]. Litter is able to change physical and chemical environment both directly and indirectly [12]. A recent study shows that addition of litters has improved the diameter growth of Dipterocarpaceae species (Parashorea tomentella, Hopea nervosa and Dryobalanops lanceolata) but does not affect the total percentage of Ectomyorrhizal (ECM) colonization [13].

In the previous study, litter production in logged-over areas (LOAs) in Sumatera under selective cutting (diameter limit for cutting >50 cm) had annual litter fall of 9.05-11.75 ton.ha\(^{-1}\) [14]. Another research reveals that to maintain content of soil organic matters in soil supporting sustainable forest management (SFM), the annual minimum number of litter production should be 8-9 ton.ha\(^{-1}\) [15]. In present study, we examine the application of TPTJ silvicultural system (diameter limit for cutting >40 cm) on litter production that may reduce number of litter fall and nutrient cycling of logged over areas (LOAs) in early time after logging. Further, it may produce negative effects on productivity of LOAs and growth of artificial plantation with strip planting technique to reach SFM. It is due to the fact that litter in forest floor is the main resource of nutrient in lowland tropical rain forest. Specifically, our study is conducted to monitor litter production in various periods of LOA that are 1, 5 and 10 years after logging and primary forest as base strip while the specific hypotheses are (1) the period after logging does not significantly affect the litter production and (2) the period after logging significantly affects the litter production.

2. Method

The research was conducted at Sari Bumi Kusuma Forest Concession, Central Kalimantan, Indonesia, at coordinate of 00º 36’ - 01º 10’ South Latitude and 111º 39’ - 112º 25’ East Longitude (Figure 1). At this place, selective cutting and strip planting with intensive silviculture technique, namely TPTJ with SILIN Technique, is applied as one of the silvicultural systems to manage the forest. The research site’s climate is type A (Schmidt and Ferguson). Moreover, mean annual temperature in nighttime and day are 22–28º C and 30–33º C respectively. The forest type of Sari Bumi Kusuma Forest Concession is lowland dipterocarps forest, dominated by family of Dipterocarpaceae [16]. The research of litter production was conducted at three periods of LOA that were 1 (L1), 5 (L5), 10 (L10) years after logging and at primary forest as a representative of development vegetation succession after logging. The data were collected in 1-ha Permanent Sample Plot (PSP) established on the various LOAs and the primary forest with 3 replications. Each PSP was established with an area of 3 square litter trap, 1 m x 1 m with 10 cm (height) at the height of 0.5 m above the soil level, both in strip planting (A) and non-strip planting (B) (Figure 2 and 3). The litter falls were collected and classified into leaves, branch and other fraction (fruit, flower, animal gust and unidentified organs). Dry weight of each fraction was determined by drying it out at temperature of 70ºC to its constant weight. The dry litter was then weighed in a unit of ton.ha\(^{-1}\). The litter dry weight was analyzed by applying one-way analysis of variance (ANOVA) to determine variation of litter production of each PSP and by Least Significant Difference (LSD) to detect any significant difference among the LOAs. The analysis was
performed using SPSS for Windows version 16.0 (SPSS Inc., Chicago). To analyze the contribution of litter falls on nutrient status, each litter harvested from litter trap was classified into leaves, branch, and other fraction (fruit, flower, animal gust and unidentified organs). Litter result is then applied to calculate the litter productivity for 6-month period and its nutrient content. Carbon (C) content was analyzed using Walkey and Black method, Nitrogen (N) was analyzed using Kjeldal method, while phosphor (P) was analyzed using wet ash method for HNO3 65% + HClO4 60%. Moreover, potassium (K) content was analyzed using wet ash methods for HNO3 65% + HClO4 60% [17].
3. Results and Discussion

Litter from forest canopy was essential for nutrients returning to forests oil [18]. The total litter production on L5 was higher than L1 and L10. The total litter production of LOA of 5 years after logging (L5) was 4.98 ton.ha⁻¹ for 6-month period. Another research shows that the litter production at tropical lowland forest at Jambi was 8.44ton.ha⁻¹.year⁻¹[19]. Those proved that strip plantation of L5 is almost similar to that of primary forest. The total litter production of L10 was 4.36 ton.ha⁻¹ for 6-month period. At L10, TPTJ silvicultural system has yet been applied, thus it does not use selected/target species. The factors affecting litter production were biotic variation, site type, standing condition and plant species. Species in L10 was not target species like in TPTJ silvicultural system. At L10, S. fallax and S. virencent were used. A previous research [20] states that at 4.5 years old, diameter growth of S. fallax was 5.6 cm and S. virencent was 6.3 cm, while on target species diameter growth of S. johorensis was 8.7 cm and S. leprosula was 8.1 cm. Strongly assumed, it would affect litter production at L10. L10 used Plantation Forest System with Cutting and Strip Planting System (HTI-TTJ) based on Decree of the Forestry Minister No.453/Kpts-II/1997 as described on technical guidance based on Decree of the Forest Minister No.453/Kpts-II/1997/IV-BPH/1997. In this system, strip planting is 3 m wide and taking clear strip 10 m wide. Planting distance in these system is 5 m and 25 m, with planting intervals 5 m and 25 m of each strip planting distance [21].

Data above shows the existing condition at every location of LOA was different. Those data shows that basal area is not always bigger even though the longer LOA is cut. It is due to the fact that cutting volume was different at every LOA location. Figure 4 shows that the basal area of L5 (19.59 m².ha⁻¹), L10 (19.34m².ha⁻¹) and L1 (14.85 m².ha⁻¹).

![Fig 3. (a) Litter trap in the non-strip planting (with existing plants) (b) Litter trap in the strip planting and (c) Litter trap in virgin forest](image-url)

![Fig 4. Basal Area and Litter Production](image-url)
The result of correlation analysis between basal area and litter production shows that the correlation value was 0.99, which means that the higher the basal area, the higher the litter production. The highest litter production was L5, with the basal area of 17.14 m².ha⁻¹, is 4.98 ton.ha⁻¹.6 months⁻¹, assuming annual litter production was 9.96 ton.ha⁻¹. The basal area in primary forest at Central Sulawesi was 390 m².ha⁻¹ and litter production was 13.67 ton.ha⁻¹.year⁻¹[22]. Those results were different from this research showing smaller basal area. This was affected by research locations concerning LOA of previous silvicultural system called Indonesian Selective Cutting System (Tebang Pilih Indonesia, TPI).

The ANOVA analysis at 95% level shows that the age (the LOA treatment) has given the significant result (F = 6.521; df=2; P=0.015) of litter production. The litter production based on observation period shows no significant results (F = 1.863; df=5) at 95% level since significance value was 0.188 (p < 0.05). The results prove that on this research, which was conducted in September, 2010 to February, 2011, the litter production was almost similar. It is possibly that there is no significant difference of season, especially in medium term. The difference of LOA also contributed in the significant result of the litter production.

Figure 5 shows that L1 has different litter production with two other locations. The difference was possibly not only because of the different basal area value in each location (Figure 4) but also the different number of trees and poles phase on stand composition. In L1, the number of trees and poles was merely 159 ha⁻¹. This is possible since there was still no natural change occurring and the impacts of the last cutting were still felt. L5 and L10 did not show any significant results, although L5 was higher than L10. This possibly caused by the difference in applied silvicultural systems. Based on ANOVA at 95% level, litter production did not show any significant results of litter trap placement at strip planting or non-strip planting (F =1.55; df=1; p=0.236). This shows that strip clearing at TPTJ system did not affect litter production in strip planting. Litter input at strip planting came from strip plants and existing stand after logging. The litter production at strip planting was not significantly different from non-strip planting, which is an advantage of TPTJ system. Beside productivity of the strip plantation, there was another advantage that is; biological diversity in non-strip planting area was not changed.

The nutrient cycling and soil fertilization process highly depend on the litter production. For 6 months of observation, the highest N total input was L5 in non-strip planting area, making up 42.2 kg ha⁻¹ which consisted of 32.5 kg.ha⁻¹ of leaves, 4.5 kg.ha⁻¹ twigs and 5.2 kg.ha⁻¹ of other fractions (Table 1). The results show that it was an adequate nutrient returns at LOA with TPTJ system, mainly from leaves fraction. N total input in tropical lowland forest at Jambi was 92.58 kg.ha⁻¹ .year⁻¹ which consisted of 31.09 kg.ha⁻¹ leaves, 14.2 kg.ha⁻¹ twigs, and the rest of other fractions [19].
Table 1. Total of Nutrient Input at Research Location

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<tr>
<th>Plot</th>
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<td></td>
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<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
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4. Conclusions

With Selective Cutting and Strip Planting System (TPTJ), the litter production is recovered after 5 years. The litter production in strip planting was not significantly different from that in non-strip planting, and that is an advantage of TPTJ system that is able to be recommended for further silvicultural system in other logged-over forests.

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