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The Litter Production and Nutrients Return of Teak Plantation Forest at East Kalimantan, Indonesia

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Abstract

The nutrients return through the forest stand litters is substantial mechanism of nutrient cycle in the forest ecosystem. The objectives of this research are to find out the litters production, the nutrient concentration of litters, and the amount of litter nutrient (N,P,K, Ca,Mg) of teak plantation forest at East Kalimantan, Indonesia. The 19 years old teak-dried litter weight more than 12. The litter is mainly composed by teak leaves elements, successively followed by other elements, such as; branch twig, tree skin and non-teak leaves elements. As a matter of fact, at all the litter elements, the higher nutrient concentration is Ca and otherwise P as the lowest. The amount of litter nutrient substance N, P, K, Ca and Mg in the 19 years-teak is more than 12 years. The amount of litter nutrient substance in both stand teaks are Ca as the most and P, conversely.

Keywords: Litter production; nutrient return; teak.

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1. Introduction

A litter is one of nutrient cycle link in the forested ecosystem which play important role in regressing the nutrients absorbed by planted root. The litter nutrient will be reserved back by teak stands wherewith its life after decomposition and mineralogy.

Litter, in ecology purposed of two understanding, i.e. (1) dead plant layered on the ground level, and (2) dead plants which are boundless toward alive plant [19]. Reference [4] defines litter as the vegetative and reproductive structured- dropping which fall caused by senescent factor, stress by mechanical factor (wind), combination of both, death and whole plant decay by wheather. The litter production is able to be classified by estimating the elements of essential production which can be accumulated on the ground level in which demineralized through decomposition phases.

The litter production plays a fundamental role in the biogeochemical cycle of organic matter and mineral nutrients thus becoming a key component in the functioning and stability of forest ecosystem [3]. The fallen-litter is a main organic nutrient reserve which substantial to systematize the most functional process taking place in the ecosystem [5]. The forested ecosystem, litter production primary depends on plant productivity, in its turn influenced by climatic and edaphics condition, biological characteristic of plant, species composition, age density, teak- stand maturity.

In the plantation forest, in which nutrient becomes commonly-restrictive factor, especially Nitrogen and Phosphor, the nutrient return into the soil is essential factor since the available nutrient is brought about by organic decomposition [5]. It takes into account that the alkaline cation stream come from is much bigger than geological and atmosphere input. Accordingly, the fast-grown and short term plantation forest governance in which long term period of soil fertility and nutrient balance, requires knowledge concerning about dynamics of litter production and nutrient cycle, litter and nutrient accumulation in the organic ground level [3]. The research objectives are to find out the litter production, the nutrient concentrates of litter, and the amount of litter nutrient (N,P ,K, Ca, Mg) of teak plantation forest at East Kalimantan, Indonesia. (Use 10 point font, times new roman) Here introduce the paper. The paragraphs continue from here and are only separated by headings, subheadings, images and formulae. The section headings are arranged by numbers, bold and 10 pt. Here follows further instructions for authors.

2. Material and Methods

2.1. Location

This research carried out in the 12 and 19 year old- teak plantation forest at PT Sumalindo Alam Lestari (unit 2), East Kutai, East Kalimantan, Indonesia which is located on 25-450 m asl. Most plantation area is addressed on 0-8° declivity. The lowest temperature is at 26,1°C and 28,5°C as the highest temperature [1]. Rely upon Schmidt and Ferguson criteria, it includes in climate B type, which has Q= 0.256. The average rainfall achieves 1.924mm per year and 162mm monthly. The average dry season is 2 months and 9 months wet season. The highest rainfall period takes place between April and June and on December, however August until September is

the lowest rainfall period. Typic Hapludalfs is researcher's soil type [11].

2.2. Method

Litter trap in every plot is 4; it's circular in 1 meter diameter. The litter removal is carried out once a month for six months. The litter taken from the trap will then be classified into teak leaves, non-teak leaves, branch, twig, and the other components (generative organ, dead organism, unidentified components), then measured to define its weight. The identical litter collected from the trap will be mixed and taken its sample, afterward weight up with dry condition. The drainage of litter component uses oven at 65°C until reaches constant weight.

Chemical analysis is done for macro nutrients such as (Nitrogen, Phosphor, Potassium, Calcium, and Magnesium); N uses Kleldahl Method; P uses Calorimetric Technique utilizes Nitric Acid Molyb date-Vanadate as dye agent and measured by spectrometer; K,Ca and Mg uses AAS (Hesse, 1971).

2.3. Data analysis

The amount of fallen- litter into forest floor and its nutrients essence for every removal is stated in dried weight unit per hectare:

$$Dw = \frac{dw}{fw} \times Fw \times \frac{10.000 (m^2)}{litter\ trap (m^2)} \dots\dots\dots (1)$$

Notice:

- Dw : Dried-weight every litter components (kg/ha)
- dw : Dried-weight litter components sample
- fw : fresh-weight litter components sample
- Fw : Total fresh-weight every litter component from 4 litter traps

The whole dried litter weight (TDw) is obtained by calculating the average Dw for 6 months multiplied by a year.

To gather the whole nutrients (TN), done this following formula:

$$TN = TDw \times c \dots\dots\dots (2)$$

Notice:

- TN = whole nutrient
- TDw = whole dried weight each component

c nutrient concentration

The amount of litter nutrient = the amount of litter nutrient of whole litter components.

3. Results and Discussion

3.1. The amount of dried weight litter

This following table is the result of dried weight litter calculation in the 12 and 19 years old-teak stand research plot.

Table 1: The Dried Weight Litter Fluctuation on Research Plots (kg/ha±Sd)

Age (year)	Month	Litter component				Total (kg/ha)	Total a year (kg/ha)
		Teak leaf	Non teak leaf	Branch twig +skin	Others		
12	1	1.038,06	19,45	14,39	21,77	1.093,67	13.124,05
	2	231,49	9,39	4,30	14,80	259,97	3.119,70
	3	285,93	9,07	1,85	38,83	335,68	4.028,20
	4	1.053,36	5,63	36,89	72,96	1.168,84	14.026,08
	5	679,08	20,40	18,02	25,43	742,93	8.915,14
	6	615,43	11,78	21,26	28,84	677,31	8.127,77
Average		650,56 ± 12,62	± 16,12	± 33,77	± 713,07	± 8.556,82 ± 322,24	± 4.106,00
		5,47	11,61	18,97	342,17	4.106,00	
19	1	1.144,35	32,98	30,18	40,65	1.248,15	14.977,76
	2	260,07	5,03	4,55	32,21	301,87	3.622,40
	3	492,61	16,07	21,07	84,67	614,43	7.373,17
	4	1.413,07	46,41	59,03	66,56	1.585,06	19.020,77
	5	569,68	18,37	34,28	59,26	681,59	8.179,08
	6	616,45	18,65	22,09	15,63	672,82	8.073,89
Average		749,37 ± 22,92	± 28,53	± 49,83	± 850,65	± 10.207,85 ± 398,29	± 5.310,72
		13,28	16,52	22,90	452,42	5.310,72	

Based on the Table 1, it can be identified that the whole amount of litter nutrient substance of 19 years old-teak is more than 12 years. The research result of [14], the elder Indian teak stand is the more amount of fallen litter.

The amount of 12 years old-teak stand litter is 8.556,82 kg/ha/year consisting of 91% leaves, 5% others components, 2% of each branch, twig, skin and non-teak leaves. The amount of 19 years old-teak stand litter is 10.207,21 kg/ha/year consisting of 88% teak leaves, 6% others components, 3% of each branch, twig, skin and

non-teak leaves.

Observed from litter production percentage in every research plot, it can be interpreted that litter is the primary composed by teak leaves, followed by other components, branch, twig, skin and non-teak leaves. The percentage of litter components, in which teak leaves, in this research is higher than other researchers conducted in any teak plantation area.

Table 2: The Leaf Component Percentage in the any Teak Plantation Forest Litter

Vegetation	Location	Leaf (%)	Sources
Teak	Nigeria	90	[17]
Teak	India	80-85	[14]
Teak	India	82	[9]
Teak	Thailand	89	[17]
Teak	India	70-90	[18]
Teak	East Kalimantan, Indonesia	88-91	This research

As the comparison toward the dried weight litter amount of teak stand in this research, in Table 3 will be shown the dried weight litter amount of any teak plantation forest.

Table 3: The Dried Weight Litter of any Teak Plantation Forest

Vegetasi	Age (year)	Location	Dried weight (kg/ha/yr)	Sources
Teak	17	Nigeria	5.067	[13]
Teak	8	Nigeria	9.020	[13]
Teak	25	Nigeria	6.043	[13]
Teak	16	Nigeria	3.774	[13]
Teak	18	India	11.255	[9]
Teak	3	East Kalimantan	11.640	[6]
Teak	6	East Kalimantan	13.200	[6]
Teak		Thailand	7.980	[17]
Teak	12	East Kalimantan	8.557	This research
Teak	19	East Kalimantan	10.208	This research

Based on the above chart, it can be concluded that the dried weight litter amount of any teak plantation forest is various. It could be relied upon interrelated factor such as; vegetation, soil fertility, and wheather [15], and

either nutrient or wind factor [8].

3.2. Litter nutrients concentration

The result of chemical analysis toward N, P, K, Ca, and Mg concentration in the litter components of 12 and 19 years old teak stand research, it is commonly known that in all litters, the highest nutrient is Ca and P as the lowest. (see Picture 1.) This is a sequence of the nutrient concentration amount of litter t 12 years- teak stand component, $Ca > Mg > K > N > P$, as the highest first, whereas the 19 years- teak stand $Ca > N > Mg > K > P$.

Some of other research results, Ca has the greatest amount of nutrient concentration, and thus there was various composition type of litter nutrient concentration that is caused by i.e. different species or vegetation type composition. The research of [12] in Avocado tree has a sequence of the nutrient concentration amount as follow; $Ca > N > K > Mg > P$, mean while [10] $Ca > K > N > P > Mg$ in the Cacao tree.

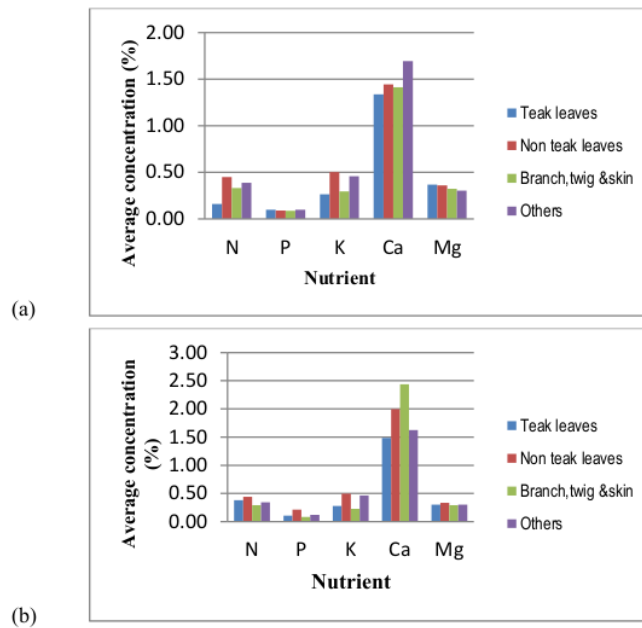


Figure 1: The Litter Nutrient Concentration of Teak Stand in the Research Plot, (a) 12 years and (b) 19 years.

The higher Ca concentrate of teak litter compared to another nutrient, is assumed relating to Ca characteristic which is more immobile than N, P, K and Mg [7]. Ca is considered unable to be moved from elder system to younger one. Moreover, [2] states that the high Ca concentration in leaves system is involved to the low mobility of Ca in the plant system caused by Ca located in a thick area as immobile treacly calcium until its physiological cycle and finally fall to the ground.

3.3. The litter nutrient

A great number of nutrients return to the forested ecosystem through fallen litter is determined by amount of biomass and litter nutrient concentration. The calculation result in amount of litter nutrient concentration at teak stand research plots is noticed as the following Table 4.

Table 4: The Amount of Litter Nutrient of Teak Stand

Age (year)	Litter component	Average nutrients (kg/ha±Sd)				
		N	P	K	Ca	Mg
12	Teak leaves	0,91±0,38	0,65±0,37	1,62±1,22	8,93±5,35	1,94±0,62
	Non teak leaves	0,06±0,06	0,01±0,01	0,07±0,04	0,18±0,12	0,05±0,04
	Branch, twig	0,06±0,05	0,02±0,01	0,04±0,03	0,23±0,17	0,05±0,03
	+skin					
	Others	0,12±0,07	0,03±0,02	0,15±0,10	0,53±0,27	0,09±0,03
	Amount	1,15±0,57	0,71±0,51	1,88±1,39	9,86±5,91	2,13±0,71
	Kg/ha/th	13,79±6,79	8,52±6,06	22,51±16,70	118,37±70,94	25,54±8,50
19	Teak leaves	3,22±2,63	0,76±0,43	1,96±1,10	11,31±7,71	2,08±0,85
	Non teak leaves	0,12±0,11	0,08±0,14	0,12±0,08	0,40±0,23	0,07±0,03
	Branch, twig	0,08±0,05	0,03±0,02	0,06±0,05	0,58±0,29	0,07±0,02
	+skin					
	Others	0,15±0,09	0,06±0,03	0,26±0,19	0,68±0,44	0,15±0,07
	Amount	3,56±2,88	0,92±0,52	2,39±1,41	12,98±8,66	2,36±0,96
	Kg/ha/th	42,70±34,61	11,00±6,20	28,70±16,97	156,70±103,97	28,31±11,54

From the Table 4, the overall litter nutrients N<P<K<Ca<Mg of 19 years teak stand is more than 12 years teak stand. Both of them contain a great number of Ca and P as the least.

In the 12 years teak stand is acquired the amount of nutrient return through litter as following sequence; Ca>Mg>K>N>P, on the other hand in the 19 years teak stand is Ca>N>K>Mg>P. Both those sequences is similar to litter nutrient concentrates of leaves components. In case of leaves components is a primary composed component of litter, in which this research has 88-91 % portion of whole litter.

Either this research finding or other research is concluded that amount of Ca in the teak, *Tectona grandis* litter is commonly known as the greatest nutrient and whereas P, except the research finding of 25 years teak stand in Nigeria. This various amount of litter nutrient is predicted involving age differences, stand density, site (edaphic and climatic (Table 5). The height of Ca and the low of P in the litter components is significantly influenced by its concentration in the litter.

Table 5: The Litter Nutrient Containt in any Teak Plantation Forest

Vegetation	Age (yr)	Nutrient containt (kg/ha/yr)					Location	Sources
		N	P	K	Ca	Mg		
Teak		25,71	6,85	9,45	69,92	11,53	India 1)	[14]
Teak		55,68	14,93	17,22	77,00	26,72	India 1)	[14]
Teak		26,16	7,30	10,18	52,52	18,66	India 1)	[14]
Teak	17	4,19	0,30	2,66	5,88	0,73	Nigeria 3)	[13]
Teak	25	49,40	18,30	30,90	66,40	15,90	Nigeria 4)	[13]
Teak	16	13,89	4,54	23,16	141,48	27,01	Nigeria 2)	[13]
Teak	18	110,26	17,50	35,03	348,97	78,46	India 5)	[9]
Teak	12	13,79	8,52	22,51	118,37	25,57	Indonesia 6)	This research
Teak	19	42,70	11,00	28,70	155,70	28,31	Indonesia.6)	This research

4. Conclusion

The entire dried-weight amount of 19 years teak stands is significantly higher than 12 years teak stand. The teak leaves component mainly composes the litter, in sequenced line with other components, branch twig and skin components, and non- teak leaves components.

It is commonly known that in whole litter component, the greatest contained nutrient concentration is Ca and the smallest is P. The whole contained litter nutrient N,P,K,Ca, and Mg of 19 years teak stand is higher than 12 years teak stand. Ca is the greatest nutrient of the whole contained litter nutrient of both teak stands, and otherwise P, as the smallest.

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