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Soil and leaf nutrient status on growth of *Macaranga gigantea* in secondary forest after shifting cultivation in East Kalimantan, Indonesia

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Abstract. *Susanto D, Ruchiyat D, Sutisna M, Amirta R. 2016. Soil and leaf nutrient status on growth of* Macaranga gigantea *in secondary forest after shifting cultivation in East Kalimantan, Indonesia. Biodiversitas 17: 409-416. Macaranga gigantea* is an important pioneer plant species in the tropical secondary forest of Kalimantan and as far the attractive wood species was not commercially cultivated. This study aims to determine the soil and nutrient status on growth of *M. gigantea* in the secondary forest particularly after shifting cultivation activity. For this purposes, the observation plots with 50m x 50m sizes were made and measured to collect the data of diameter, height, soil conditions and leaf nutrient concentrations (N, P and K) of *M. gigantea* in different ages of natural growth. A simple linear correlation analysis was used to determine the relationship of plant growth with the leaf and soil nutrient concentrations as well. The results showed that the soil condition on growth of *M. gigantea* has the average at pH 4.7, CEC 5.57 meq/100g, base saturation 30.22%, and the concentration of soil nutrients were 0.062±0.015% (N), 12.65±4.9 ppm (P), and 57.76±33 ppm (K). We also found that the leaf nutrient concentration was 1.94±0.13% (N), 0.22±0.08% (P) and 0.66±0.27% (K), respectively. Moreover, the highest growth of diameter was found from the 6 years old of plant (27.88 m). The annual yield of diameter and high were 4.65 cm $year^{-1}$ and 2.96 $year^{-1}$ and it was gradually decreased until the 10 years old of plant. The negative correlations was observed from the soil nutrient K and growth of diameter and high of *M. gigantea* (r=0.95, $p< 0.05$). The positive correlation was observed from the P and K content in the leaf of plant and growth of *M. gigantea* (diameter, height and volume increment, $p<0.1$). We suggested that phosphorus and kalium content was play an important roles on the growth of *M. gigantea* and this nutrient factor should be considered well when this species will be cultivated for the commercial purposes in the future.

Keywords: *Macaranga gigantea*, nutrient status, soil condition, secondary forest

INTRODUCTION

Shifting cultivation or slash-and-burn farming or swidden agriculture, is an age-old and prevailing subsistence farming practice in the tropical regions, and is one of the traditional practices of forest and land management (Imang et al. 2008; Inoue et al. 2010; Comte et al. 2012; Li et al. 2014). Generally, shifting cultivation involves three essential features: (i) the clearing of natural vegetation, (ii) a cropping period, usually one to three years, and (i) iia fallow period, 10-20 years, during which the land is abandoned to natural vegetation. Usually the fallow period must be longer the cropping period. Traditionally, in many areas, it is 10-20 years or more, but with increasing population density, the fallow period will decrease dramatically (Gauguin et al. 2002). Shifting cultivation system adopted by the Dayak Kenyah people in Samarinda, East Kalimantan, Indonesia an area of forest is cleared usually rather incompletely, the debris is burnt, and the land is cultivated for a few years-usually less than five years-then allowed reverts to forest or secondary vegetation (fallow period) before being cleared again. The average of fallow period in Pampang Village, Samarinda was 6-10 years and forest reopened limited to young secondary forest. The purpose of this shifting cultivation is to rest the land so that the land can be fertile again and replanted (Lahji et al. 1992; Imang et al. 2008). Imang et al. (2008) classified fallow periods among the Kenyah in four categories commonly used at field sites: shrub vegetation (0-2 years), young secondary forest (5-8 years), old secondary forest (more than 9 years), and primary forest. During the fallow period, soil fertility is regenerated through naturally occurring processes. The different mechanisms are partly related to build-up of nutrients in plant biomass, litter layer and soil organic matter during the succesional reforestation under the fallow period (Gauguin et al. 2002). The accumulation of nutrients in plant biomass is affected by soil fertility and crop species. When compared, relatively fertile Inceptisol soil accumulated considerably more nutrients than the less fertile Oxisol. A two year *Piper aduncum* fallow accumulated twice as much nitrogen (N), three times as much phosphorous (P), almost seven times as much potassium (K) and twice as much calcium (Ca) and magnesium (Mg) than did a two year *Imperata cilindrica* fallow (Noordwijk et al. 2008).

Macaranga gigantea is a fast-growing pioneer species in secondary tropical rain forests, and abundantly in the open *mixed dipterocarp* forests after shifting cultivation (Lawrence 2001; Lawrence 2005; Kiyono and Hastaniah 2005; Susanto et al. 2015). Imang et al. 2008 reported that

Kenyah farmers also recognize some dominant species in secondary forests (fallow period) that indicate the land is fertile or not fertile for rice cultivation (cropping period). *Macaranga* is important indicator species of trees in young and old secondary forests. When the species found are dominant and grow well in a certain area, it means that the land is fertile enough for cropping period. Information about flowering, fruiting and seed germination also has been reported by Susanto et al. (2016). On the other hand, *M. gigantea* has not yet been cultivated and information about soil, leaf nutrient status, growth and its correlation from naturally succession in various tread and age in secondary forests is not yet known.

One of approaches in determining fertilizer requirements on plants which can be applied properly is soil analysis. Plant tissue analysis is more practical to determine nutrient status on plant than other methods. Plant tissue generally analyzed is leaf. Nutrients in leaves not only have a role in photosynthesis but also represent plant nutrient status. Leaves also consist of tissues which always available for analysis of plant nutrient status. Leaf analysis has been used as indicator in nutrient diagnosis and as basic recommendation for fertilizer application on fruit crops at some countries (Smith 1962; Leece 1976; Shear and Faust 1980; Liferdi et al. 2008). Kim et al. (2015) reported the foliar N and P concentration could be used as a parameter to assess the nutrient environments of tree species restored in a fire-disturbed urban forest. Singh (2006) also reported that the growth rates (height, diameter and volume increment) were positively related to foliar N and P concentration.

Therefore, here in this research we focus our work on soil and leaf nutrient status of *M. gigantea* in fallow period of shifting cultivation areas. By obtaining information about soil and leaf nutrient status of this plant, expected to support if this species will be cultivated for the commercial purposes in the future.

MATERIALS AND METHODS

Study area

This research was conducted in Pampang, Sungai Siring (village of Dayak Kenyah), Samarinda, East Kalimantan, Indonesia. It was located between the coordinates of $00^0$20'15.4"-$00^0$21'58.8" South and $117^0$13'46.6"-$117^0$14'11.0" East (Figure 1). The average of annual rainfalls (2003-2013) was 2423 mm, the highest annual rainfall interception was 2757.5 mm in 2008. The highest monthly rainfall interception was in April (288.3) and the lowest was in August (115.3 mm). Wet period occurs between 9-12 months, while dry period occurs between 0-3 months. Average monthly temperature was 27.5^0 and average air humidity was 82% (Anon. 2012; Susanto et al. 2016). Soil and leaf nutrient analysis, and data analysis were conducted in the Soil Science Laboratory at the Faculty of Forestry and Plant Physology Laboratory, Faculty of Mathematics and Natural Sciences, Universitas Mulawarman, Samarinda, East Kalimantan, Indonesia. The research was conducted from July 2011 to January 2012.

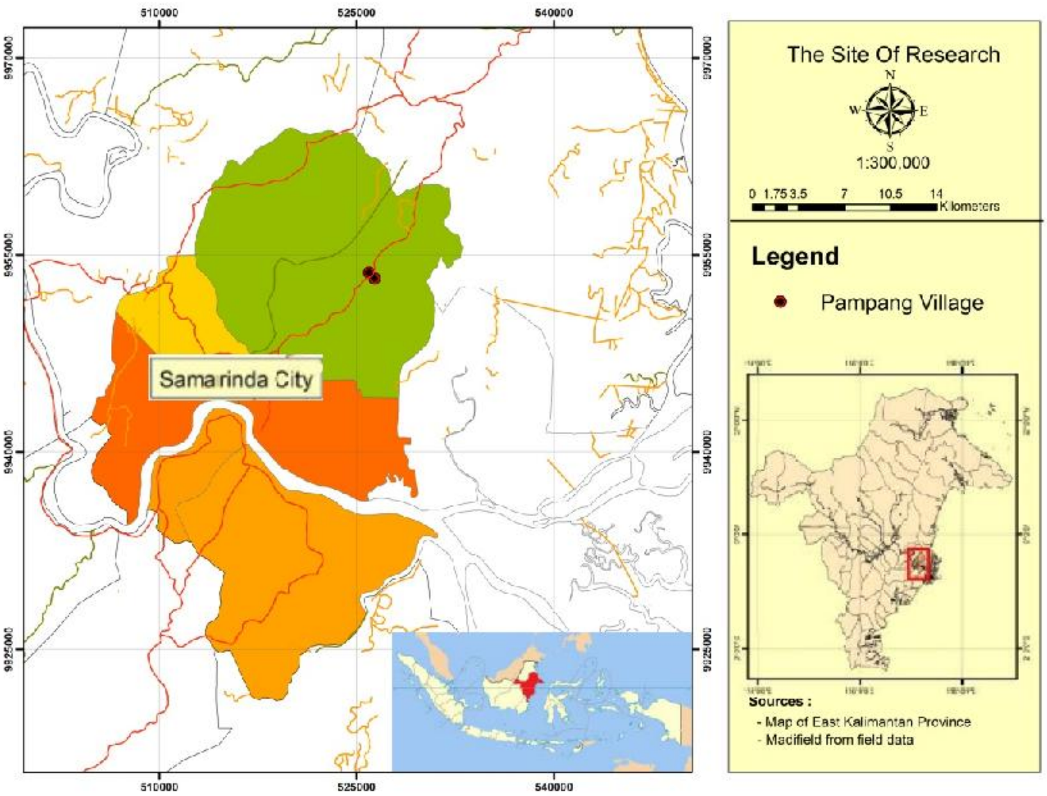

Figure 1. Map of study area in fallow period shifting cultivation at Pampang Village Samarinda, East Kalimantan

Procedures

Research in the area of fallow periods shifting cultivation begins by conducting interviews with land owners (farmer) to obtain information about shifting cultivation cycles, location and age of fallow lands. For each age fallow land made one plot size of 50 m x 50 m. Coordinate point is determined using GPS, then measuring the following: number of trees *M. gigantea*, diameter and height of trees, sampling the soil and leaf of *M. gigantea*.

Measurement of diameter and height M. gigantea

On each plot was measured *M. gigantea* plants, include: the number of trees; diameter at breast height (dbh); and height (h) is measured with clinometer.

Soil sampling

Soil sampling was conducted in all research plots with drill ground at a depth of 0-30 cm and 30-60 cm. On each plot was take 4 point drilling, soil samples composited for each plot. Composite soil samples were then taken 500 g of each class of depth, put into plastic bags, labeled and transported to the laboratory to be analyzed concentration nutrient elements (C, N, P, K).

Sampling leaf M. gigantea

Leaf sampling conducted in all research plots using a pole. In each plot, four trees set an example. The leaves of the tree each sample is then taken in such a way by observing the position of the individual components of the canopy leaf vertically (bottom, middle and top) and horizontal position of each of these components in the stem (the part closest, medium and farthest part). Further examples of composite leaf for each study plot, sampled 500 g, put in plastic bags and transported to the laboratory to be analyzed concentration nutrient elements (N, P, K).

Soil analysis

Soil sample was taken from the depth of 0-30 cm, 30-60 cm and the results were calculated after being dried in the oven with the temperature of 150^0C until constant weight was reached. Composite sample was air-dried and its pH, base saturation, cation exchange capacity, organic carbon content, total Nitrogen (Kjendal), available phosphor (Bray), available potassium were analyzed.

Analysis on leaf nutrient concentrations

The total N concentrate was measured using Kjeldahl method (extraction, distillation, and titration). To measure the element of P and K, the plant components were extracted using High Pressure Digestion method at the temperature of 180^0C for 10 hours with HNO_3 as a reductant. Phosphor was measured by using calorimetric technique and using nitrate-molybdate-vanadate acid as a coloring agent and was measured by using spectrophotometer at the wavelength of 470 nm. Potassium (K) was measured by using Atomic Absorption Spectrophotometer at the wavelength of 766,5 nm, 489,5 nm and 245,2 nm.

Data analysis

The data obtained from the observation in the field, soil and leaf concentration were analyzed descriptively. Correlation between soil N, P, K concentration (X) with leaf N, P, K concentration and growth of *M. gigantea* (Y) was explored through regression analysis, for significance through a two-tailed Student's t-test (p= 0.05-0.10).

RESULTS AND DISCUSSION

Soil chemical properties

Results of soil chemical analysis showed that the soil pH range between 4.4-4.7 with an average of 4.63 ± 0.11 that included the category of acid and very acid. Cation exchange capacity is very low (3.66 to 4.96 meq. $100g^{-1}$) to low (5.64 to 7.63 meq $100gr^{-1}$) with average 5.90±1.18 meq $100gr^{-1}$. Effective base saturation is medium and low (24.81 to 43.43%) at a depth of 0-30 cm and the status of low and very low (9.19 to 33.14%) at depth of 30-60 cm. Base saturation tends to decrease from the fallow period of 0.5 to 6 years and increased again in the fallow period 7 to 10 years (Table 1)**.**

Results of soil chemical analysis showed that the carbon concentrations ranged from 0.3 to 0.78% with the average of 0.53 ± 0.17 with a very low status. A carbon nutrient concentration in the 0-30 cm soil depth class is always greater than 30-60 cm soil depth class on all plots. The concentration of N status is very low in the range of 0.04 to 0.09% with the average value of 0.062 ± 0.015. Further away from the surface of the soil, the concentration of N decreased in all study plots. The concentration of P has the status of extremely low (5.33 ppm) to high (24.23 ppm) with the average of 12.65 ± 4.9 which is low. Phosphorus nutrient concentrations at a depth of 30-60 cm class are always better than for the class of 0-30 cm depth. The concentration of K nutrient status is very low (17.11 ppm) to low (122.56 ppm) with average 57.76 ± 33.8 were classified as very low. Kalium nutrient concentrations in the 0-30 cm soil depth class higher than the class of the depth of 30-60 cm, has a tendency to continue to decline until the fallow fields 6 years and increased again in the fallow period of 7 years and 10 years (Table 2).

Plant growth

The results of the field studies showed that *M. gigantea* found on fallow land age of 0.5 years to 10 years. Fallows old 0.5 years, the mean diameter is 0.73 cm, with 0.58 m height that still includes categories seedling. A 2 years, the mean diameter *M. gigantea* is 2.27 cm and 3.03 m heigh. *M. gigantea* in fallow land 3 years, the average diameter is 6.05 cm with a height of 5.69 m. Fallow land 6 years, the average diameter was 27.88 cm and a height of 17.74 m. Fallow land 7 years the average diameter *M. gigantea* is 22.02 cm and heigh is 15.37 m. *M. gigantea* in fallow land 10 years the average diameter is 26.79 cm and height 18.17 m. The study showed that highest mean diameter (27.88 cm) was obtained in *M. gigantea* from fallow 6 years old, then decreased. Diameter and height growth increment of the largest (4.65 $cm.yr^{-1}$ and 2.96 m. $year^{-1}$) obtained on the plant from fallow 6 years old and continued to decline until the age of 10 years (Table 3).

Table 1. Soil chemical properties in each age fallow period shifting cultivation in Pampang Village, Samarinda, East Kalimantan

Fallow lands old (yr)	Soil depth (cm)	Soil chemical properties		
		pH (H_2O)	CEC (meq.100 g^{-1})	BS (ppm)
0.5	0-30	4.7	6.10	37.31
	30-60	4.7	6.38	30.23
2	0-30	4.6	6.81	43.43
	30-60	4.7	7.63	28.57
3	0-30	4.7	6.59	32.86
	30-60	4.6	7.01	25.18
6	0-30	4.7	3.77	24.81
	30-60	4.8	3.87	9.19
7	0-30	4.4	5.36	41.11
	30-60	4.5	6.35	29.09
10	0-30	4.5	5.30	40.74
	30-60	4.6	5.64	33.14
Mean		0.53±0.17	4.63±0.11	31.30±93

Note: CEC= cation excange capasity, BS= base saturation

Table 2. Soil Nutrient concentration in each age fallow period shifting cultivation in Pampang Village, Samarinda, East Kalimantan

Fallow lands old (yr)	Soil depth (cm)	Soil nutrient concentrations			
		C (%)	N (%)	P (ppm)	K (ppm)
0.5	0-30	0.71	0.07	14.25	104.24
	30-60	0.39	0.05	17.82	122.56
2	0-30	0.77	0.08	5.70	90.87
	30-60	0.33	0.06	24.23	78.09
3	0-30	0.74	0.07	12.83	72.43
	30-60	0.37	0.04	15.68	27.84
6	0-30	0.78	0.08	9.76	31.45
	30-60	0.30	0.05	18.3	17.11
7	0-30	0.55	0.06	7.13	45.31
	30-60	0.32	0.04	10.69	19.64
10	0-30	0.76	0.09	5.33	50.37
	30-60	0.35	0.04	10.13	33.14
Mean		0.53±0.17	0.062±0.015	12.65±4.9	57.76±33.8

Leaves nutrient concentrate

Result of leaf analysis showed that *M. gigantea* leaves from fallow land shifting cultivation had different N, P, K concentrations. The concentration of N in the leaf *M. gigantea* in the range of 1.75 to 2.12%, with the average 1.94% ± 0: 13. Concentration of P has a range from 0.14 to 0.36%, and K has from 0.37 to 1.06%, by average, respectively 0.8% ± 0.22 (P) and 0.66% ± 0.27 (K). The concentration of N, P, K leaf *M. gigantea* increased until the age of 6 years and then declining age of 7 and 10 years old.

Correlation between plant growth with soil and leaf N, P, K concentration

The concentration of nitrogen and phosphorus in the soil does not correlate with the diameter and height of plants *M. gigantea*, whereas the concentration of potassium in the soil at a depth of 0-30 cm and 30-60 cm negatively correlated with stem diameter, height, diameter increment, height increment and volume increment. Results of t- test on the value of r shows that statistically significant ($p < 0.05$). (Table 5, and Figure 3).

The relationship between the concentration of nutrients P, K leaves with average stem volume and volume increment, statistically significant for the elements K, and diameter increment and height increment statistically significant for the elements P. (Table 6, Figure 4).

Table 4. Concentration of leaf nutrient *M. gigantea* in each age fallow period shifting cultivation in Pampang Village Samarinda.

Fallow land old (yr)	Leaf nutrient concentrations		
	N (%)	P (%)	K (%)
0.5	2.00	0.18	0.61
2	1.89	0.14	0.38
3	1.89	0.25	0.56
6	2.12	0.36	0.85
7	2.00	0.20	0.37
10	1.75	0.15	1.06
Mean	1.94±0.13	0.22±0.08	0.66±0.27

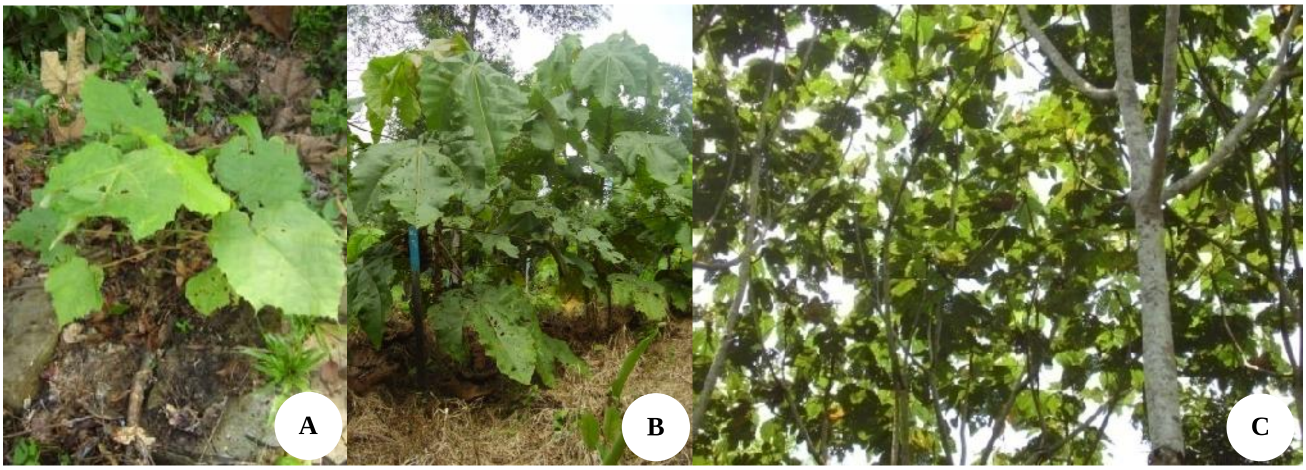

Figure 2. *Macaranga gigantea* plants: A. seedling, B. sapling, C. mature trees

Table 3. Data inventory vegetation of *M. gigantea* in each age fallow period shifting cultivation in Pampang Village, Samarinda

Fallow land old (yr)	N 2500m$^{2-1}$	N ha^{-1}	Diameter (cm)	Height (m)	Volume (m^3 ha^{-1})	Diameter increment (cm th^{-1})	Height increment (m th^{-1})	Vol increment (m^{3}ha^{-1}th^{-1})
0.5	9	36	0.73	0.58	0.0005	0.73	0.580	0.0005
2	38	152	2.27	3.03	0.13	1.1	1.135	0.065
3	12	48	6.05	5.69	0.44	2.0	2.017	0.147
6	5	20	27.88	17.74	11.06	4.65	2.96	1.843
7	9	36	22.02	15.37	8.77	3.2	2.196	1.253
10	12	48	26.79	18.17	25.88	2.7	1.870	2.588
Mean						2.4±1.4	1.8±0.8	0.9±1.1

Table 5. Correlation coefficient from results regression analysis and p-value for significance throught t-test between soil nutrient concentration and growth of *M. gigantea*

Soil concentration	Depth (cm)	D	t	H	t	V	t	DI	t	HI	t	VI	t
N (%)	0-30	0.29	0.585	0.28	0.596	0.566	0.223	0.10	0.850	0.06	0.911	0.505	0.305
	30-60	0.47	0.352	0.50	0.316	0.472	0.344	0.34	0.509	0.40	0.432	0.441	0.381
P (ppm)	0-30	0.48	0.339	0.52	0.289	0.881	0.232	0.25	0.627	0.22	0.672	0.818	0.265
	30-60	0.73	0.195	0.63	0.176	0.084	0.146	0.38	0.458	0.35	0.502	0.105	0.183
K (ppm)	0-30	0.95	**0.04**	0.96	**0.03**	0.666	0.149	0.97	**0.01**	0.94	**0.05**	0.823	**0.04**
	30-60	0.77	**0.07**	0.81	**0.05**	0.498	0.314	0.83	**0.04**	0.93	**0.007**	0.622	0.187

Note: Bold values denote significance at p < 0.05. D= stem diameter, H= stem height, V= volume of stem, DI= diameter increment, HI= height increment, VI= volume increment and t = t-test values.

Table 6. Correlation coefficient from results regression analysis and p-value for significance throught t-test between leaf nutrient concentration and growth of *M. gigantea*

Leaf concentration	D	t	H	t	V	t	DI	t	HI	t	VI	t
N (%)	0.09	0.863	0.03	0.952	0,388	0.445	0.42	0.413	0.32	0.539	0.15	0.773
P (ppm)	0.41	0.417	0.38	0.463	0,010	0.954	0.74	**0.094**	0.75	**0.082**	0.20	0.700
K (ppm)	0.60	0.212	0.56	0.234	0,789	**0.062**	0.41	0.420	0.32	0.542	0.76	**0.081**

Note: Bold values denote significance at p < 0.10. D= stem diameter, H= stem height, V= volume of stem, DI= diameter increment, HI= height increment, VI= volume increment and t= t-test values

Discussion

The soil chemical properties in this study area pH (H_20) is very acid to acid reaction, cation exchange capacity is very low to low and effective base saturation is low to medium at a depth of 0-30 cm and 30-60 cm. Base saturation tends to decrease from the fallow lands of 0.5 to 6 years and increased again in the fallow lands 7 to 10 years (Table 1**).** Ruhiyat and Lahjie (1992) reported that the soils in fallow lands of shifting cultivation systems of Dayak Kenyah in Barong Tongkok, East Kalimantan, have very acid to acid reaction, with pH (H_2O) value of 4.0-5.2. Effendi et al. (2009) also reported that the soil properties in fallow lands under intensified shifting cultivation systems in Sarawak, Malaysia could be characterized by a strongly acidic nature with low levels of exchangeable bases. During the fallow, soil organic carbon, cation exchange capacity (CEC), nitrate, total phosphorous, and extractable basic cations all manifest positive associations with fallow length after 3 to 11 yr of fallow. No declines in soil parameters were detected between plots based on the frequency of past slash-and-burn activity (Kleinman et al.1996).

The soil carbon, nitrogen and phosporus concentrations in this study area a very low, phosphous has the status of extremely low (Table 2). Ruhiyat and Lahjie (1992) also reported that status carbon concentration ranges 2.6 to 5.9% in 1 month fallow periods, increases by 4.3-7.2% and 5.7-14% in the fallow periods of 2 and 3 years. At plots with a longer fallow period it is obvious that the carbon concentration decreases again. Nitrogen concentration in 1 month fallow periods shows the lowest value (0.34%), increase up to the fallow 3 years (0.64%), and N concentration to decrease to 0.58% in fallow periods 5 years. The decrease in N concentration continues until the fallow periods 8 years (0.33%), and fallow period of 35 year 0.43%. At plots with duration of up to 2 year for the fallow period the P concentration is lowest (0.3-0.9 ppm), increasing to 2.7-17.3 ppm at fallow period 3-5 year, P concentration decreases again with longer fallow period 8 and 35 years. K concentration at plot the plot with fallow

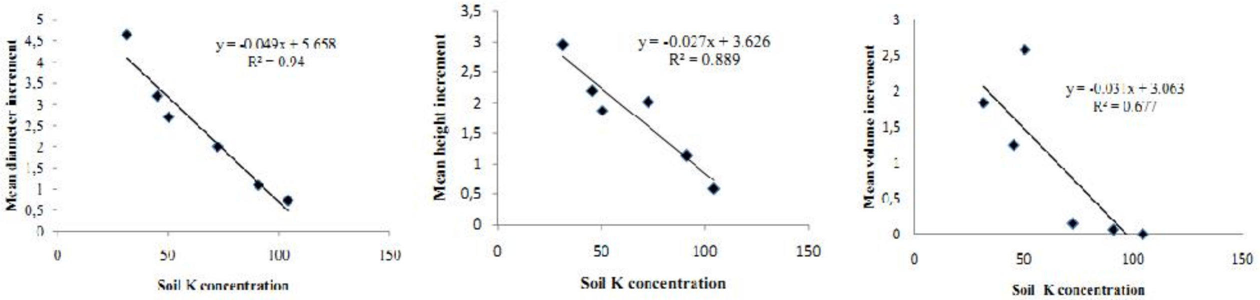

Figure 3. Relationships between soil K concentration and growth of trees *M. gigantea* at fallow periods shifting cultivation. (a) diameter increment Vs soil K concentration (0-30 cm) (b) height increment Vs soil K concentration (0-30 cm), and (c) volume increment Vs soil K concentration (0-30 cm).

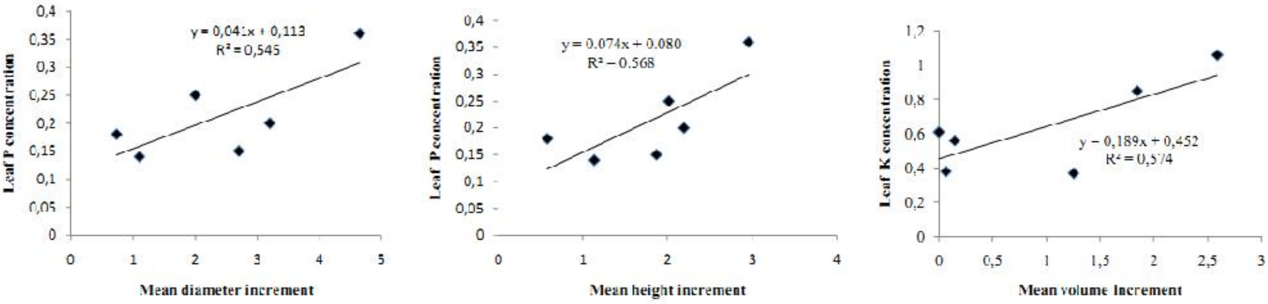

Figure 4. Relationships between leaf P and K concentration with growth of trees *M. gigantea* at fallow periods shifting cultivation. (a) diameter increment Vs leaf P concentration (0-30 cm) (b) height increment Vs leaf P concentration (0-30 cm), and (c) volume increment Vs leaf K concentration (0-30 cm).

period of 2-5 years show a relative increase, then its decrease again at plots with a fallow period of 8 to 35 years. Funakawa et al. (2010) reported that he soils in East Kalimantan were generally less fertile. The lower N availability could be ascribed to the loss of N from soil ecosystems and the insufficient recovery of soil N pools under poor vegetation regrowth due to intensive land use in this area (Effendi et al. 2009). Styger et al. (2007) recommended that upland agricultural intensification and diversification based on improved soil fertility through optimized organic and inorganic inputs and fire-less land management that encourages the re-establishment of nutrient stocks. The study showed that highest mean diameter (27.88 cm) was obtained in *M. gigantea* from fallow 6 years old, then decreased. Diameter and height growth increment of the largest (4.65 $cm.yr^{-1}$ and 2.96 m. $year^{-1}$) obtained on the plant from fallow 6 years old and continued to decline until the age of 10 years (Table 3). Hiratsuka et al. (2006) reported that the average stem diameter of *M. gigantea* at the age of three years after forest fire in East Kalimantan, Indonesia was 4,6 cm (average diameter increment was 1,53 cm). On the other side, Davies et al. (1998) reported that the diameter growth of *M. gigantea* was 0.22 mm $year^{-1}$, at seedling or sapling stratum was 0.22 mm $year^{-1}$, 0.37 mm $year^{-1}$ at reproductive stratum, 0.74 mm $year^{-1}$ at reproductive stratum and 0.39 mm $year^{-1}$ at mature stratum (Figure 2). Compared with this data, our results showed that the diameter increment and height of *M. gigantea* in fallow after shifting cultivation activity was higher than previously reported.

Imang et al. (2008) reported that in shifting cultivation, vegetation succession more real existence and simpler for farmers instead of using the number of years of fallow period. The condition of vegetation, especially of key species is a direct indication of the level of soil fertility. If farmers describe the plot of fallow land to describe the status of their real ecological succession. If the indicator species has grown and become the dominant vegetation, it means that the land was fertile and cleaned ready for replanting. Farmers use their experience and knowledge with a view vegetation species key to determiner that particular plot of a land enough fertile for farming use. In Pampang, *Blumea balsamifera* is a good indicator species of vegetation most fertile soil in the shrub vegetation, while *Macaranga triloba* is a tree species important indicator for young secondary forests. *Macaranga spp, Hibiscus macrophylus, Spatholobus oblongifolius* are important indicators for the old secondary forest. Tree species important indicator for primary forest is *Shorea* spp. If the species were discovered dominant and growing in a certain area, it means that the land is enough fertile for farming. Cultivators Kenyah also recognize some dominant species in secondary forest indicates that the soil is not fertile.

These species include *Dicranopteris linearis, Melastoma malabatricum, Imperata cylindrica, Oncosperma horridum* and *Tristaniopsis whiteana*.

The leaf nitrogen concentration in this study is 1.94% ± 0: 13 (1.75 to 2.12%), concentration of P has a range from 0.14 to 0.36%, and K has from 0.37 to 1.06%, by average, respectively 0.8% ± 0.22 (P) and 0.66 ± 0.27% (K) (Table 4). Ishida et al. (2004) reported the N concentrate ranged between 15-20 mg g^{-1}, while phosphor concentrate ranged between 1.7 to 2.7 mg g^{-1} in seedling canopy *M. gigantea*. On the other hands, it was also reported that the highest nitrogen concentrate of *M. gigantea* leaves which grow naturally was 2.5 mol kg^{-1} and 2.0 mol kg^{-1} when the plant was growth under sapling stratum; and the lowest nitrogen concentrate was found at seedling, sucker stratum and mature stratum, that only gave 1.5 mol kg^{-1}. Breulmann et al. (2002) stated that phosphorus concentrate on *Macaranga* growth in the natural forests in Malaysia was ranged between 0.06 to 0.09%, while potassium content was 0.71 to 0.82%, respectively. The largest size of *M. gigantea* leaves was found at sapling stadium, reaching 60 cm long and 50 cm wide (Okuda 1996; Silk et al. 2000). The same is expressed by Gauguin et al. (2002) that the biomass of leaves and nutrients stored in leaf increased rapidly in the first years of fallow shifting cultivation, where after it will reach its maximum level. Nutrients more concentrated on the delicate parts of the plant such as leaves, twigs and small branches rather than the more rugged components such as rods. Delicate parts only make up a small proportion of secondary forests growing older but often have a large proportion of total nutrients in above-ground biomass. The nitrogen content in the biomass secondary forest stands ex-shifting cultivation increases linearly only up to 5 years. After this initial period the leaf canopy is fully developed and the increase in weight of the stand increases in nitrogen poor bole material. For biomass of P on the same tendency that increased linearly only up to 7 years, being the elements K and Ca are very similar to N. During the first years the availability of nutrients K are relatively high but when taken out of many available nutrients taken with a strong and next at a lower rate. Likewise, the Mg nutrients are just higher at the beginning of growth

The correlation between growth of *M. gigantea* trees with soil nutrient concentration at a depth of 0-30 cm, 30-60 cm statistically significant only in the element of K (p=0.05), while for the other elements are not significant. Concentration of potassium in the soil at a depth of 0-30 cm and 30-60 cm negatively correlated with stem diameter, height, diameter increment, height increment and volume increment (Table 5, Figure 3). *M. gigantea* growth was negatively correlated with soil K concentration. Based on the r-value, soil K concentration had moderately correlated with *M. gigantea* growth. The r-value of 0.96 and 0.77 showed that 96% and 77% variance of *M. gigantea* growth change could be explained by soil K concentration variable, while the remain of 4% and 23% could be explained by other factors.

On the other hand, relationships between the concentration nutrients of foliage *M. Gigantea* and growth of *M. gigantea*, statistically significant (p=0.10) for nutrient P and K (Table 6, Figure 4). Liferdi et al. (2008) reported that calibration test gives meaning of leaf analysis value obtained from laboratory become interpreted data, whether nutrient concentration in leaf is very low, low, moderate high, and very high. Only plants having low nutrient concentration require fertilizer. Kim et al. (2015) reported that the foliar N and P concentration could be used as a parameter to assess the nutrient environments of tree species restored in a fire-disturbed urban forest.

In the tropical rain forests of East Kalimantan servings of nutrient base class (K, Ca and Mg) more accumulates on vegetation than in the soil, while the portion of nutrient N largely accumulates in the soil (Ruhiyat 1993), and in forest plantation reported that plant forests of *Eucaliptus deglupta* and *Paraseriantes falcataria* at the age of 5-10 years in East Kalimantan also accumulate nutrient element of K in a largest amount, followed by calcium, nitrogen and magnesium. Therefore, the availability nutrient element of K to fulfill the need of *Eucalyptus deglupta* stand should get a prioritized attention. In the other parts of natural forests in East Kalimantan show that 70 to 94% of base elements exist in the stand biomass (Ruhiyat 1993; Meckensen 1999; Meckensen et al. 2001).

In conclusion, soil condition of *M gigantea* in fallow periods has the average at pH 4.63±0.11, CEC 5.90±1.18 meq $100g^{-1}$, base saturation 31.30±0.93%, and the concentration of soil nutrients were 0.062±0,015% (N), 12.65±4.9 ppm (P), and 57.76±33.8 ppm (K). We also found that the leaf nutrient concentration was 1,94±0,13% (N), 0,22±0,08% (P) and 0,66±0,27% (K), Diameter and height increment of the largest (4.65 cm yr^{-1} and 2.96 m $year^{-1}$) obtained on the plant *M. gigantea* at fallow land 6 years old and continued to decline until the age of 10 years. The negative correlations was observed from the soil nutrient K and growth of diameter, high, diameter increment, high increment and volume increment of *M. gigantea* (p=0.05). The correlation between the concentration of N leaf with diameter and hight stem statistically not significant, but for P leaf nutrient statistically significant with diameter increment and height increment, and K leaf nutrient with stem volume and stem volume increment.

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REFERENCES

Anon. 2012. Meteorology, climatology and geophysics station of Temindung Airport, Samarinda, East Kalimantan. Indonesia.

Breulmann G, Markert B, Weckret V, Herpin U, Yoneda R, Ogino K. 2002. Heavy metals in emergent trees and pioneers from tropical forest with special reference to torest fires and local pollution sources in Serawak. Malaysia. Sci Total Environ 285: 107-115.

Comte I, Davidson R, Lucotte M, De Carvalho CJR, Oliveira FDA, Da Silva BP, Rousseau GX. 2012. Physicochemical properties of soils in the Brazilian Amazon following fire-free land preparation and slash-and-burn practices. Agric Ecosyst Environ 156: 108-115.

Davies SJ. 1998. Photosynthesis of nine pioneer *Macaranga* species from Borneo in relation to life history. Ecology 79: 2292-2308.

Effendi MBW, Tanaka S, Joseph JK, Logie S, Brangking U, Jonathan LAT, Arifin A, Yoshinori M,, Sakurai K. 2009. Vegetation conditions and soil fertility of fallow lands under intensified shifting cultivation systems in Sarawak, Malaysia. Tropic 18 (3): 115-126.

Eichhorn KAO. 2006. Plants diversity after rain-firest fires in Borneo. Blumea Suplement 18 Nationaal Herbarium Netherland, Universiteit Leiden branch, Leiden.

Funakawa S, Yonebayashi K, Kaewkhongkha T, Makhrawi. 2010. Soil ecological study on shifting cultivation in Southeast Asia. Faculty of Natural Resources, Prince of Songkla University, Thailand. http: //natres.psu.ac.th.

Hiratsuka M, Toma T, Diana R, Hadriyanto D, Morikawa Y. 2006. Biomass recovery of naturally regenerated vegetation after the 1998 forest fire in East Kalimantan, Indonesia. JARQ 40 (3): 277-282.

Imang N, Inoue M, Sardjono MA. 2008. Tradition and the influence of monitary economy in swidden agriculture among the Kenyah People of East Kalimantan, Indonesia. Int J Soc For 1 (1): 61-82.

Inoue Y, Kiyono Y, Asai H, Ochiai Y, Qi J, Olioso A, Shiraiwa T, Horie, T, Saito K, Dounagsavanh L. 2010. Assessing land-use and carbon stock in slash-and-burn ecosystems in tropical mountain of Laos based on time-series satellite images. Int J Appl Earth Obs Geoinf 12: 287-297.

Ishida A, Yazaki K, Hui AL. 2004. Ontogenetic transition of leaf physiology and anatomy from seedlings to mature trees of a rain forest pioner three *Macaranga gigantea*. Oxfort J 25 (5): 513-522.

Kim C, Jeong J, Park JH, Ma HS. 2015. Growth and nutrient status of foliage as affected by tree species and fertilization in a fire-disturbed urban forest. Forests 6: 2199-2213.

Kiyono Y, Hastaniah. 2005. Patterns of slash-and-burn land use and their effects on forest succession: Swidden-land forests in Borneo. Bull For For Prod Res Inst 4 (4): 259-282.

Kleinman PJA, Bryant RB, Pimentel D.1996. Assessing ecological sustainability of slash-and-burn agriculture through soil fertility indicators DOI: 10.2134/agronj1996.00021962008800020002x

Lahji A, Sukmananto, Hadikusumah, Iskandar H, Abdoelah J, Wangsadidjaya. 1992. Datarban’s changing lanscape: imperata and out-migration. In: Poffenberger M and McGeant B (eds), Communities and forest management in East Kalimantan, pathway to environmental stability. Center for Southeast Asia Studies International and Area Studies University of California, Berkeley.

Lawrence D. 2001. Nitrogen and phosporus enhances growth and luxury consumption of four secondary forest tree species in Borneo. J Trop Ecol 17: 859-869.

Lawrence D. 2005. Biomass accumulation after 10-200 years of shifting cultivation in Bornean rain forest. Ecology 86: 26-33.

Leece DR. 1976. Diagnosis of nutritional disorder of fruit trees by leaf and soil analysis and biochemical indices. J Aust Inst Sci 42: 3-19

Li P, Feng Z, Jiang L, Liao C, Zhan J. 2014. A Review of Swidden Agriculture in Southeast Asia. Remote Sens 6: 1654-1683.

Liferdi, Poerwanto R, Susila AD, Idris K, Mangku IW. 2008. Correlation test of leaf phosphorus nutrient with mangosteen production. Indonesian J Agriculture 1 (2): 95-102

Manokaran N, Kochummen KM. 1992. Tree growth in primary lowland and hill dipterocarp forests. J Trop For Sci 6 (3): 332-345.

Meckensen J, Ruhiyat D, Folster H. 2001. Volume-based Nutrient content of *Acacia mangium, Eucalyptus deglupta* and *Paraserianthes falcataria* in industrial tree plantations in East Kalimantan, Indonesia. J Trop For Sci 13: 512-526.

Meckensen J. 1999. Nutrient management for industrial tree plantation: A practical guidance towards integrated nutrient management. Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ) GmbH Postfach 5180. D-65726 Eschborn.

Noordwijk MV, Mulyoutami E, Sakuntaladewi N, Agus F. 2008. Swiddens in transition: shifted perceptions on shifting cultivators in Indonesia. World Agroforestry Centre ICRAF Southeast Asia Regional Office, Bogor.

Okuda T. 1996. Studies on potentials growth and photosynthesis capacity of trophical tree seddlings. National Institute for Environmental Studies, Environment Agency, Japan.

Romell EG, Hallsby G, Karlsson A, Garcia C. 2008. Artificial canopy gaps in a *Macaranga* spp. dominated secondary tropical rain forest—Effects on survival and above ground increment of four under-planted dipterocarp species. For Ecol Manag 255 (7): 1452-1460.

Ruhiyat D, Lahji A. 1992. Development of soil properties and productivity in different succession stages of swidden cultivation systems of Dayak Kenyah in East Kalimantan. Ann Rep Pusrehut 2: 1-17.

Ruhiyat D. 1993. Dynamics of nutrient in natural and plantation forest: Cycle of forest biogeochemistry. Prosiding workshop to construction of tropical rain forest with vision of environment to increase productivity. Universitas Mulawarman and Indonesian Forestry Departement, Samarinda, 1-3 Marc 1993. [Indonesian]

Ruhiyat D. 1996. Biomass estimate of tropical rain forest in East Kalimantan. Rimba Kalimantan 1 (1): 42-57. [Indonesian]

Shear CB, Faust M. 1980. Nutritional ranges in deciduous tree fruits and nut. Hort. Rev 2: 142-163.

Singh A. 2006. Growth and leaf nutrient status of companion species as influenced by neighbouring species in mixed plantations raised on mine soil. Trop Ecol 47 (2): 259-269.

Slik FJW, Bernard CS, Van Beek M, Breman FC, Eichhorn KAO. 2008. Tree diversity, composition, forest structure and aboveground biomass dynamics after single and repeated fire in a Bornean rain forest. Oecologia. DOI 10.1007/s0042-008-1163-2.

Smith PF. 1962. Mineral analysis in plant tissue. Ann Rev Plant Physiol 13: 81-108.

Styger E, Rakotondramasy HM, Pfeffer MJ, Fernandes ECM and, Bates DM. 2007. Influence of slash-and-burn farming practices on fallow succession and land degradation in the rainforest region of Madagascar. Agric Ecosyst Environ 119: 257-269.

Susanto D, Akhriady A, Purnomo H. 2015. Site condition and presence of *Piper aduncum* in secondary forests. BioProspek 7 (2): 2015. [Indonesian]

Susanto D, Ruhiyat D, Sutisna M, Amirta R. 2016. Flowering, fruiting, seed germination and seedling growth of *Macaranga gigantea*. Biodiversitas 17 (1): 192-199.