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LEAF NUTRIENT STATUS IN THE LOWLAND DIPTEROCARP FOREST

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ABSTRACT

Study on leaf nutrient status in the primary lowland dipterocarp forest has been carried out at Mulawarman University research forest, Lempake, Samarinda. Six elements i.e. N, P, K, Na, Ca and Mg were analyzed. Results show that the dominant species and family seemed to be controlling and maintenance the main mineral nutrients in this forest ecosystem. There were a variation of mineral nutrients between species and also a fluctuation of mineral nutrients in the different period.

ABSTRAK

Suatu pengamatan terhadap status hara makanan pada daun di hutan pamah primer Dipterocarpaceae telah dilakukan dihutan penelitian Universitas Mulawarman, Lempaks, Samarinda. Enam macam hara yaitu N,P,K, Na.Ca dan Mg telah diukur kandungannya. Hasil pengamatan menunjukkan bahwa jenis dan suku dominan mengatur dan mengontrol hara makanan utama pada ekosistem hutan ini. Variasi kandungan hara jelas terlihat pada jenis-jenis berbeda dan juga terlihat adanya fluktuasi kandungan hara pada periode waktu yang berbeda.

INTRODUCTION

Plant analysis as a tool for assessing the nutrient status or requirement of plants is not new. Such a concept was already expressed more than a century ago by Wienhold in 1862 (Smith 1962). Plant analysis has extensively been employed in agricultural research (Kenworthy 1967, Chapman 1967). In general the richest tissue with the highest concentrations are those where the metabolic activities are the greatest. For most plants the richest organs are the shoot apices and leaves. Woody tissues generally have much lower concentration, but because of their bulk may contain a large proportion of the total elemental content of the plants.

The contents of mineral elements in leaves of forest trees can vary appreciably during the vegetation period as a result of changes in metabolism, transport within the plant and leaching by rainfall (tamm 1951, Likens & Bormann 1970). The seasonal changes in chemical composition of tree species in the Northern Hemisphere are relatively well understood, but those in subtropical and tropical areas are poorly known.

The aims of this study are to determine the mineral element contents of leaves from the most dominant tree species in the primary lowland diptero-carp forest. It is hoped that those species may controle the nutrient in the forest ecosystem, since it is generally assumed that in the tropical rain forest, most of nutrients are bound in the vegetation.

STUDY AREA AND METHODS

The forest under consideration was primary Mixed Dipterocarp Forest (MDF) near Samarinda, East Kalimantan described in detail by Riswan (1982; 1985).

Leaf material were collected from 35 common tree species based on the number of individual tree and the total of basal area. They were collected three times a year with a lapse of six months from the similar trees, that is in February, August and February coming year. This trees are the common trees, out of 209 species from 1.6 ha Riswan's control plot (1982; 1987).

There are inherent difficulties in sampling tree leaves. Nutrient contents are known to differ between sun and shade leaves in a tree. In the present study, in order to. minimize the variability and to increase standardisation, the speciemens of tree leaf are collected from the base part of canopy. Swan (1962) and Gagnon (1964) mentioned that the analytical results of nutrient leaf content from lower canopy samples are as well correlated with site nutrient indices as upper crown values.

Leaf samples were soon dried in the field, kept inside newspaper and stored in cardboard boxes, until the leaf samples were brought to laboratory. To make sure that leaf samples were dry and ready for grinding, the leaf speciemens were placed in an oven for 24 hours at 80°C.

Specimens were ground by using a hammer mill and sieved by 0.7 mm standard mesh size before analysis. The preparation of sample solution sui-table for elemental analysis by using a acid digestion method. N-content in the leaf was determined using a Technicon Autoanalyser following acid digestions. P in the sample was estimated as a phosphate by Molybdenum Blue Method (Allen et al. 1974). This method basically a colorimetry. K and Na were measured by emmission spectrophotometry, using a UNICAM SP 900 Series 2 Spectrophotometer; and for Ca and Mg were measured by atomic absorption spectrophotometry; using a similar instrument to that for K and Na.

RESULTS AND DISCUSSIONS

SEASONAL LEAF NUTRIENT

The results of nutrient elements in the leaves (Table 1) show seasonal fluctuations of nutrient elements in the leaves during study period. This agrees with reported studies in Temperate zones (Likens & Bormann 1970, Tamm 1981) and in tropical regions (Nye 1961, Ernst 1973 and Golley e;t aL 1975).

Table 1. Mean of leaf-mineral nutrient in Lempake Forest, Samarinda (N and P in % and other elements in mg/100 *g)*

Elements *	Period of collection		
	February 1978	August 1978	February 1979
N	1.41 ± 0.07	1.68 ± 0.08	1.51 ± 0.07
P	0.12 ± 0.003	0.20 ± 0.01	0.13 ± 0.01
K	602.14 ± 39.00	1016.42 ± 59.67	823.17 ±82.52
Na	56.84 ± 3.14	23.36 ± 1.00	55.05 ± 1.93
Ca	552.94 ± 46.49	540.29 ± 45.13	539.80 ± 44.95
Mg	229.61 ± 32.06	247.25 ± 43.17	241.14 ± 47 22

* Value of element = mean of 35 species ± standard error

According to Duvigneaud and Denaeyer-De Smet (1970) there are three possible causes of the seasonal fluctuation of nutrients in the leaves, those are the forest canopies (leaves) are very efficient in capturing airborne dust particles, leaching of nutrients from the leaves by rain water and transfering of nutrient minerals from the leaves before they fall as litters. There is of course the natural build up within a leaf with ages. Rodin and Bazilevich (1967) reported that the amount of elements leached from the forest canopies in temperate zones are less than in tropical forest. They also mentioned that the degree to which elements are leached from the crown of trees also varies to some extent between species.

Kenworthy (1971) in his studies at Malayan tropical forest found that the content of K in rain water passing through the canopy has increased eight times and for Ca increased about three times. It is an evidence that pattern and rate of element mobilities within the nutrient cycling are differences; Therefore, it indicates that K is a mobile element and Ca is less mobile. The main factors possibly influence the leaf nutrient fluctuations are such as the differences of leaf nutrient mobilities in soil vegetation system, leaching of the rain water, transport within the plant, the ability of nutrient uptake and soil microorganism activities.

NUTRIENT STATUS WITHIN SPECIES

Table 2 shows the mean value of each species within one year period and marked variations in mineral nutrient concentration within and among species. There are many reasons for this variation, such as seasonal factor, age of leaf and tree, position of leaf within the canopy, soil fertility and some . competation factor between plants, i.e. moisture, light, temperature and elevation (Driessche 1974).

Table 2. Mean of leaf-nutrient mineral for 1 year period at Lempake Forest, Samarinda
(% for N and P; and mg/100 g for K, Na, Ca and Mgj

No.	Species	N	P	K	Na	Ca	Mg
1	*Shorea leprosula*	1.73	0.12	515.56	32.94	532.22	118.00
2	*S. assamica* vai. *globifera*	1.67	0.17	934.44	40.11	926.44	183.22
3	*S. parvifolia*	1.80	0.16	594.44	38.61	637,66	160.83
4	*S. smithiana*	1.15	0.14	414.44	55.11	451.22	116.39
5	*S. palembanica*	,1.76	0.14	556.67	45.22	435.28	123.83
6	*S. ovalis* spp. *ovalis*	1.40	0.17	447.78	42.39	422.94	90.89
7	*S. polyandra*	1.71	0.28	539.45	40.38	692.39	223.33
8	*Dvyobalanops beecarii*	1.02	0.12	765.56	48.89	673.56	251.67
9	*Hopea rudiformis*	1.92	0.23	734.44	46.33	430.78	116.67
10	*Dipterocarpus cornutus*	*0.93*	0.14	518.66	45.11	525.00	119.22
11	*Monocarpia marginalis*	2.55	0.13	408.34	57.00	902.22	185.78
12	*Palaquium hexandrum*	1.43	0.12	916.67	53.56	777.67	244.94
13	*Pentace laxiflora*	2.04	0.17	1153.33	52.39	589.78	237.33
14	*Litaea* sp.	1.84	0.21	1078.89	36.39	607.17	139.72
15	*Eusideroxylon z wager i*	1.30	0.13	1265.00	59.39	386.50	237.83
16	*Eugenia suringarianum*	1.47	0.11	1067.22	61.83	553.50	164.00
17	*E. sibulanensis*	1.14	0.11	1120.00	51.67	505.39	225,78

No.	Species	N	P	K	Na	Ca	Mg
18	*Syzygium rncemosum*	1.08	0.12	328.33	42.67	518.17	225.17
19	*Koordesiodendron pinnatum*	1.39	0.17	1308.89	43.72	1004.78	275.33
20	*Artocarpus tamaran*	1.81	0.11	757.78	48.11	488.61	195.67
21	*Glochidion loistylum*	1.40	0.16	741.11	52.00	541.39	380.11
22	*Mallotus muticus*	1.36	0.13	1077.22	75.95	1188.00	1544.44
23	*Baccaurea macrocarpa*	0.69	0.12	982.22	42.28	999.00	263.22
24	*Cleistanthus myrkmthus*	*1.31*	0.13	836.67	47.55	567.11	174.33
25	*Gordonia excelsa*	0.82	0.14	510.00	42.89	475.60	112.72
26	*Elaeocarpun acmocefolius*	.1.39	0.17	605.55	49.83	588.39	249.89
27	*Paranephelium* sp.	1.36	0.11	408.33	41.56	478.17	118.50
28	*Intsia palembanica*	2.34	0.19	1097.22	47.78	460.55	203.50
29	*Ochanostachys amentacea*	1.77	0.14	997.78	45.94	180.22	88.78
30	*Scorodocarpus borneensis*	2.25	0.22	897.78	48.61	230.00	151.06
31	*Dillenia eximia*	1.17	0.12	701.67	50.44	297.61	16.5.22
32	*D. excelsa*	1.04	0.14	1452.22	55.39	256.83	324.83
33	*Diospyros macrophylla*	1.26	0.13	457.22	38.66	88.67	560.00
34	*Quercus gemmelifiora*	1.45	0.18	745.55	40.44	569.83	116.83
35	*Ryparosa javanica*	2.18	0.17	1156.11	54.55	540.-00	351.67

It is suggested that each of plant species has own capacity to uptake nutrient from the soil and store them in the leaves. This capacity will be filled to various degrees depending upon the species in competation with it and the general part of nutrients available for all species. A good example is *Intsia palembanica* (Leguminosae) what has a high N-leaf content. This is not surprising because many leguminous plants have N-fixation microorganism in their roots. In the overall patern of the ecosystem the,total nutrient uptake will depend upon the product of production of individual species and its nutrient content per unit weight.

In Table 3 the maximum and minimum values within one year period are recorded for range of species at primary dipterocarp forest plot. The comparison of the maximum and minimum values, with the standard content of leaf nutrient given by Allen et al. (1974) demonstrated that top level for P and Mg are much higher, N is more or less equal and for K, Na and Ca are much lower. However, it suggested that leaf nutrient status in plants are varies between forest ecosystem.

Table 3. The maximum and minimum values of leaf-nutrient content within one year period in Lempake forest, Indonesia

Elements	Contents (%)					
	Maximum			Minimum		
	Feb 78	Aug 78	Feb 79	Feb 78	Aug 78	Feb 79
N	2.62 I. pal	2.92 M. mar	2.42 M. mar	0.76 G. exe	0.79 G. exc	0.90 G, exc
P	0.17 I. pal	0.38 H. rud	0.37 S. pol	0.07 D. cor	0.04 G. exc	0,05 E. sib
K	1.10 E. zwa	1.60 K. pin	2.25 D. exc	0.16 S. smi	0.36 D. mac	0.21 S. smi
Na	0.10 M. mut	0.05 M. mut	0.08 M. mut	0.03 L. sp	0.02 D. exi	0.03 S. bor
Ca	1.35 M. mut	1.16 M. mut	1.06 M. mut	0.10 D. mac	0.10 D. mac	0.07 D. mac
Mg	1.37 M.mut	1.53 M. mut	1.73 M. mut	0.08 0. ame	0.09 S. ova	0.08 S. ova

Note :

I. pal = *Intsia palembanica*
M. mar = *Monocarpia marginalis*
H. rud = *Hopea rudiformis*
E. sib = *Eugenia sibulanensis*
S. smi = *Shorea smithiana*
D. mac = *Diospyros macrophylla*
D. exc = *Dillenia excelsa*
O. ame = *Ochanostachys amentacea*
S. bor = *Scorodocarpus borneensK*
G. exc = *Gordonia excelsa*
D. cor = *Dipterocarpus cornutus*
S, pot = *Shorea polyandra*
E. zwa = *Eusideroxylon zwageri*
*K. pin** = *Koordesiodendron pinnatum*
M. mut = *Mallotus muticus*
S. ova = *Shorea ovalis spp.ovalis*
L. sp = *Litsea* sp.
D. exi = *.Dillenia eximia*

The interesting species which have a high nutrient status, are as follows:

1. *Instia palembanica* (Leguminosae) which has the highest N-content. It well known among tropical leguminous trees that it has a prolonged seed dormancy. It is a big, straight tree with a smooth bole, and often became one of the emergent tree in the forest. Four other species which also have

N-content > 2% axe *Monocarpia marginalis* (Annonaceae), *Ryparosa javanica* (Flacourtiaceae) *and Pentace laxiflora* (Tiliaceae). All these species are small to medium trees.- It means at least 5 species in five families involved for maintaining of N within forest ecosystem. The similar results that Leguminous tree has high N-leaf content are recorded by Nye (1958) in Ghana forest and Riswan (1977) for leaves from Serawak and Barro Colorado, Panama forest.

2. *Mallotus muticus* (Euphorbiaceae), a small to medium tree, common and with the high density of individual tree. The leaf mineral content of Ca, Mg and Na is the highest among the dominant trees. This species is suspected as a fast growing species since it was very common in young secondary forest; if it is true, this another evidence that fast growing tree species have high leaf-nutrient content (Riswan 1977). The other extra-ordinary of this species was Mg-leaf content > Ca > K. It is an unusual occasion, and it is also found in leaf of *Diospyros macrophylla* (Ebenaceae).

3. *Eusideroxylon zwageri* (Lauraceae), which the most dominant species in term of number of individual tree per ha, medium to big tree, very slow growing (Meiyer 1974) and most of tree in this forest are mature trees (between 200-300 years old; Riswan, et al. 1985). It has very high of K-leaf content, together with soecies of *Dillenia excelsa* (Dilleniaceae) and *Koordesiodendron pinnatum* (Anacardiaceae). The last two species are small to medium trees.

4. *Shorea polyandra* and *Hopea rudiformis* (Dipterocarpaceae), both have the highest P-leaf content, medium to big tree and most' of them are the emergent trees. Dipterocarpaceae is a dominant family in term of total basal area.

From the obtained data, it was clear that the dominant tree species or family indicate to maintenance and control the nutrient mineral in the forest ecosystem. It is very important since in the tropical rain forest, the most of available nutrient are bound in the living sistem (vegetation).

Ashton (1973) said that P and K were the critical nutrient elements in soil at soil of Sarawak lowland dipterocarp forest and it was supported by Golley et al. (1975) from Panaman tropical forest. It means that P and K are the limiting factor in the tropical rain forest. The present data from Lempake forest demonstrate that P and K are bound by the most dominant families those are Dipterocarpaceae and Lauraceae. Both families are the most commercial timber in lowland dipterocarp forest, therefore it might be the answer why the effect of forest disturbences in the tropical lowland dipterocarp forest, i.e. shifting cultivation and logging operation cause a jeopardize in the whole forest ecosystem and leading to alang-alang (*7m-perata cylindrica)* fields or wasting lands.

NUTRIENT STATUS WITHIN FAMILY

To test whether there is grouping of species which is belong to one family based on leaf-mineral contents, an ordination by using a principal component analysis (PCA) programme has been used (Fig. 1). The results show that species from each family built up their own group (family). It is clear that most of families have high N- and P-leaf levels, except Euphorbiaceae (No. II) has very high of Ca and Mg (particularly *Mallotus muticus,* no. 22) and also K and Na levels. Dipterocarpaceae (No. I) shows-the highest P-leaf content and also N, Ca and Mg. Olacaceae (No. V) is also high in leaf-

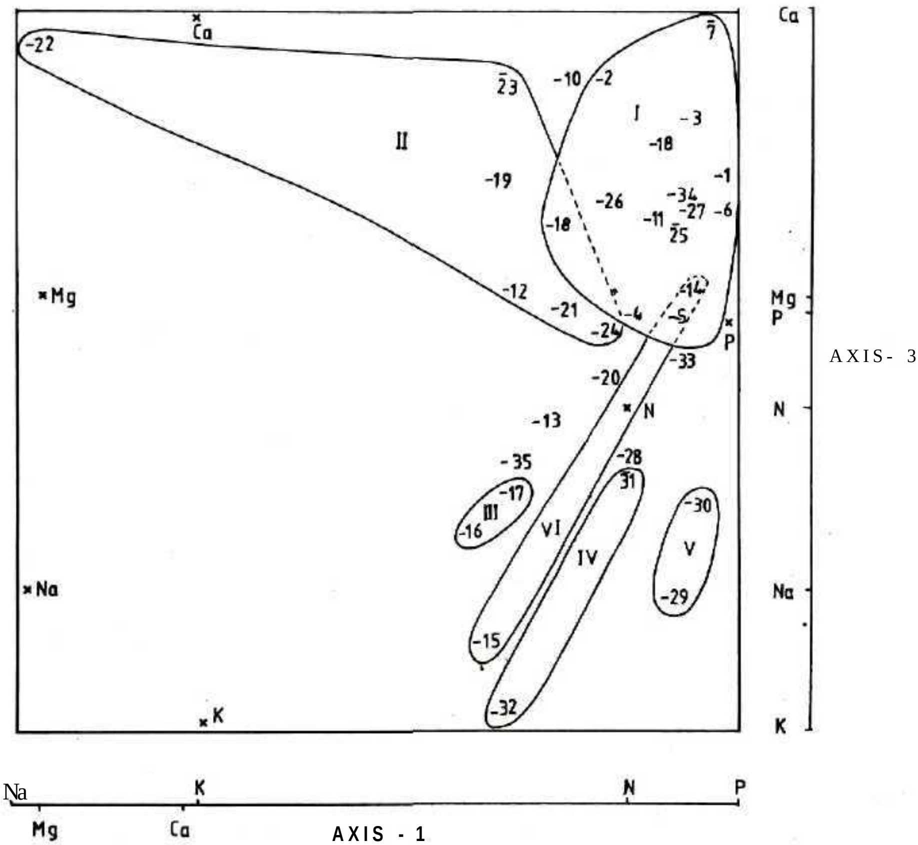

Fig. 1. Principal Component Analysis ordination of species and six leaf-nutrient variables of primary dipterocarp forest, Lempake, Samarinda, Legend. I-Dipterocarpaceae. II-Euphorbiaceae. III-Myrtaceae. IV-Dilleniaceae. V-Oleaceae. VI-Lauraceae. List of species (No 1 to 35) see Table 2.

content of N, P, K, and Na. Lauraceae (No. VI) particularly species of *Eusideroxylon zwageri* (no. 15) and Dilleniaceae (No. IV) show the highest of K-leaf level and also high content in N, P, and Na. Leguminosae *(Intsia palembanica*, .no. 28), Tiliaceae *(Pentace laxiflora)* and Flacourtiaceae *(Ryparosa javanica*, no. 35) show a high of N-leaf content. This data support Riswan (1977) based on analysis of Sarawak and Barro Colorado leaf specimens:

NUTRIENT STATUS IN GENERAL

A comparison between leaf-nutrient from Lempake forest and some other tropical rain forest (Table 4) show that most of nutrient elements seem to be in low level compare to other tropical forests^ except for K,Na and Ca which they are higher than Stark's (1971a, 1971b) results. It is not surprised due to this forest grow on podzol soil which it is known very poor in soil nutrient and low pH.

P-leaf level in Lempake forest is more or less similar to the other forests and slightly higher than in Kumasi, Ghana and Yangambi, Belgian Congo forests. The table also performs that P-leaf is the lowest content compared with other macronutrient, i.e. N, K, Ca and Mg. It suggests that P-soil level is very low in tropical lowland forests (Ashton 1973, Golley et al. 1975).

Ashton (1973) and Withmore (1974) have approved that there is a strong indication that P-soil level can be an important factor for determining the distribution of species diversity in the tropical rain forest. Ashton (1973) stated that species diversity appeared the greatest in the range 40-150 ppm of total P-soil and declined both below and above these levels. The present study in Lempake forest resulted 131.08 ppm of P-soil content (Table 5). Tree species composition in Lempake forest (209 species per 1.6 ha) supported this hypothesis.

The leaf- and soil-nutrient elements (Riswan 1982,1985) in the lowland primary dipterocarp forest at Lempake can be ranked as follows N > K > Ca > Mg > P > Na (leaf-nutrient) and N > Ca > Mg > K > P > Na {soil-nutrient). It is obvious that soil-nutrient is considerably lower than in leaf-nutrient, therefore it is reasonable that most of nutrient in the tropical rain forest is stored in vegetation. The results suggest that vegetation in tropical rain forest are extraordinary efficient at conserving nutrient levels which they required for maintaining their dynamic equilibrium.

Table 4. Comparison of leaf-nutrient of Lempake Forest, Sam ar in da with other Tropical Forests

Site	Mean of leaf-nutrient content (%)						Remarks
	N	P	K	Na	Mg	Ca	
Lempake, Samarinda (present study)	1.53	0.15	0.81	0.05	0.54	0.24	Mean of 35 species; 1 year period; RYP soil
Bukit Mersing Sarawak (Riswan 1977)	2.99	-	0.9.6	0.09	1.22	0.32	Mean of 20 species basalt soil
Bukit Iju, Sarawak (Riswan 1977)	2.25	-	0.89	0.09	0.41	0.29	Mean of 21 species; rhyolite soil
Barro Colorado Island, Panama (Riswan 1977)	3.53	—	1.48	0.21	1.15	0.29	Mean of 15 species; basic volcanic ash soil
Kumasi and Pakoase District, Ghana (Nye 1958a)	2.00	-	0.93	—	1,57	1.54	Mean of 66 species;
Kumasi, Ghana (Nye 1958b)	2.52	0.14	0.85	-	1.54	0.48	Mean of 14 species
Yangambi, Belgian (Greenland and Kowal 1960)	2.20	0.12	1.24	-	1.18	1.18	Data from 18 years old forest
Darien, Panama (Goliey et al 1975)	2.00	0.16	1.35	0.16	1.66	0.31	
Montane Forest, Puerto Rico (Ovington and Olson 1970)	1.60	0.78	1.04	0.20	1.01	0.37	
Amazone forest (Stark 1971a and. 1971b)	2.29	0.18	0.75	0.03	0.30	0.26	Forest on podzol **soil**
Over all tropical forests (Rodin and Bazile-vich 1967)	2.25	0.17	0.95	0.05	1.00	0.30	Mean of 34 species

Tabel 5. Comparison of mean leaf-nutrient and soil-nutrient in Lempake Forest, Samarinda, Indonesia (based on data February 1978)

Kind of items	Elements (ppm)					
	N	P	K	Na	Ca	Mg
Leaves (mean of 35 species)	14100	1200	6021.40	568.40	5629.40	2296.10
Soil (0-10 cm) (mean of 9 samples)*	2500	5.30 (Available) 131.08 (Total)	175.95	48.28	1691.38	308.10

Note : * : based on Riswan (1982)

CONCLUSIONS

Data from the present study in the lowland primary dipterocarp forest have given a further advance evidence about leaf-nutrient as a part of nutrient cycling in the tropical rain forest, that is :

1. Leaf-nutrients fluctuate following the time or have a seasonal change.
2. Leaf-nutrient levels are higher compared with soil nutrient levels; Therefore, this supports the hypothesis that total plant nutrient in the tropical rain forest is stored in vegetation.
3. The dominant species and families tend to control the nutrient cycling in the tropical rain forest.
4. Phosporous and potassium seem the most critical elements in the plant-soil system in tropical rain forest,
5. Plants in tropical rain forest have an extraordinary efficient at conserving nutrients.

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