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ON THE NUTRIENT CONTENT OF TREES OF DRY EVERGREEN FOREST IN NORTHEASTERN THAILAND

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บทคัดย่อ

การวิจัยเรื่องนี้ได้วิเคราะห์ความเข้มข้นของธาตุอาหารในส่วนที่อยู่เหนือผิวดินของพันธุ์ไม้ป่า ๔๐ ชนิด ซึ่งขึ้นอยู่ในป่าดิบแล้งบริเวณสถานีฝึกนิสิตมหาวิทยาลัยขอนแก่น (เขื่อนอุบลรัตน์) ซึ่งอยู่ห่างจากตัวเมืองขอนแก่นไปทางตะวันตกประมาณ ๑๔๐ กม. ความเข้มข้นของธาตุอาหารในส่วนใดส่วนหนึ่งของต้นไม้ผันแปรไปตามชนิดพันธุ์ไม้อย่างกว้างขวาง ไม่ปรากฏว่ามีความสัมพันธ์ที่เด่นชัดระหว่างความเข้มข้นของธาตุอาหารกับขนาดของต้นไม้ และความแตกต่างระหว่างชนิดพันธุ์ไม้ก็ไม่มีนัยสำคัญด้วย ธาตุอาหารบางชนิด เช่น ไนโตรเจนและฟอสฟอรัสในใบเปลี่ยนแปลงไปตามพื้นที่ใบจำเพาะ ความเข้มข้นของไนโตรเจนในใบสัมพันธ์กับฟอสฟอรัสและโพแทสเซียม ส่วนแคลเซียมมีความสัมพันธ์กับแมกนีเซียม ความเข้มข้นของแคลเซียมและแมกนีเซียมในป่าแห่งนี้มีค่าสูงกว่าในป่าอื่น ๆ เท่าที่ได้มีการศึกษามา ความสัมพันธ์ระหว่างขนาดของต้นไม้และปริมาณการสะสมธาตุอาหารไว้ในส่วนต่าง ๆ ที่อยู่เหนือผิวดินได้นำมาวิเคราะห์ รวมทั้งได้สร้างสมการแสดงความสัมพันธ์ของธาตุแต่ละธาตุไว้ในรายละเอียดแล้ว

ABSTRACT

The nutrient concentration was analyzed for above ground part of 40 trees in a dry evergreen forest in Khon Kaen University Farm at Chulabhorn Dam, about 140 km. West from Khon Kaen City. The nutrient concentration rather widely varied from tree to tree within same organ. The factors concerning those variations were examined. However, there was no clear relationship between nutrient concentration and tree size for each organ, and the difference between species was not significant. While, some nutrient elements such as nitrogen and phosphorus in leaves changed with specific leaf area. Nitrogen concentration in leaves was rather related with phosphorus and potassium, and calcium concentration was related with magnesium. Calcium and magnesium concentrations in this forest were higher than the other forest reported. The relationships between tree size and the accumulation of nutrient in the above ground part of tree were examined, and the equations were determined for each element.

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INTRODUCTION

Trees, their stems, branches, roots and leaves are one of the major pool of nutrient in a forest ecosystem, because considerable amount of nutrient is stored in trees of well developed forest. A part of the stored nutrient recycle through litterfall with death of leaves, branches and stems. Therefore, the studies about the nutrient contents of trees are very important for understanding the cycling of nutrient of a forest ecosystem, while, those studies are rather few, particularly for tropical forest. There are some studies about the nutrient concentration of tree leaves, but the studies on stems, branches and roots are very few. It would mainly due to the difficulty of collecting materials for analysis of stems and branches.

The present study deal with the nutrient concentration of each organ of above ground part of individual tree, including various tree species of various size. Based on those results, the amount of nutrient accumulated in above ground part of tree is also estimated.

EXPERIMENTAL SITE AND METHODS

The study was carried out in a natural dry evergreen forest developed in the farm of Khon Kaen University at Chulabhorn Dam, Amphoe Khon San, about 140 km west of Khon Kaen, located on the upperstream of the Nam Phrom River. The elevation is around 800 m, and the topography of the area is rolling and hilly.

The field investigation was carried out in Dec. 1979-Jan. 1980 and Oct. 1981, in the natural dry evergreen forest. Sixty trees larger than 4.5 cm in DBH were cut and the weight of leaves, branches and stems were measured with the measurement of diameter and height. Among those sixty trees, forty trees were selected, and samples of leaves, branchesand stems of those for by trees were collected for chemical analysis. All leaves of an individual tree were thoroughly mixed and a part of them was collected for chemical analysis. Several branches varying in size were selected from all branches of an individual as the materials for chemical analysis. Three disks with nearly equal thickness were taken from lower, middle and upper parts of a stem as a sample of stem for individual.

The floristic composition and structure of the studied stand and the method adopted for biomass measurement were reported in detail in the previous paper (T.Tsutsumi, *et al.*, 1983).

The samples collected were air dried and pulverized before chemical analysis. Nitrogen was determined by C-N Corder (Yanagimoto). The mineral nutrient was

analysed for the solution digesting organic materials with a mixture of 30% perchloric acid and 70% nitric acid. Calcium and magnesium were determined by atomic absorption spectro-photometer, potassium by flame photometer and phosphorus by the molybdenum blue procedure.

RESULTS AND DISCUSSION

Difference of Concentration of Nutrient Element Between Individuals.

The concentrations of each element varied in rather wide range within same organ. Nitrogen concentration (%) ranged from 1.07 to 3.14 for leaves, and 0.19 to 0.58 for stems. Calcium concentration (%) ranged from 0.47 to 3.74 for leaves and 0.34 to 1.74 for stems. Mean concentrations and standard deviations are shown in Table 1. Those variations would be attributable to various factors such as size of trees, characteristics of species, age of tree and so forth.

1. Size of Tree and Nutrient Concentration

Fig. 1 shows the relationship between tree size and nutrient concentration for nitrogen and phosphorus, respectively. It is clear that the concentration do not change with tree size, though there is big difference in tree size, i.e., from 5.1 to 55.3 cm in DBH. The result was same for the other element, and the similar results were reported by Tsutsumi (1971) and Tanner (1977). Therefore, it is likely that difference of tree size is not the major cause of the variation of concentration.

Table 1. Average concentrations of nutrient elements for each organ with standard deviations (%)

	N	P	K	Ca	Mg
Leaves	1.83 ± 0.55	0.13 ± 0.03	0.91 ± 0.46	2.12 ± 0.89	0.93 ± 0.55
Branches	0.64 ± 0.19	0.08 ± 0.05	0.34 ± 0.13	1.26 ± 0.48	0.33 ± 0.33
Stems	0.34 ± 0.10	0.05 ± 0.03	0.16 ± 0.06	0.79 ± 0.45	0.11 ± 0.14

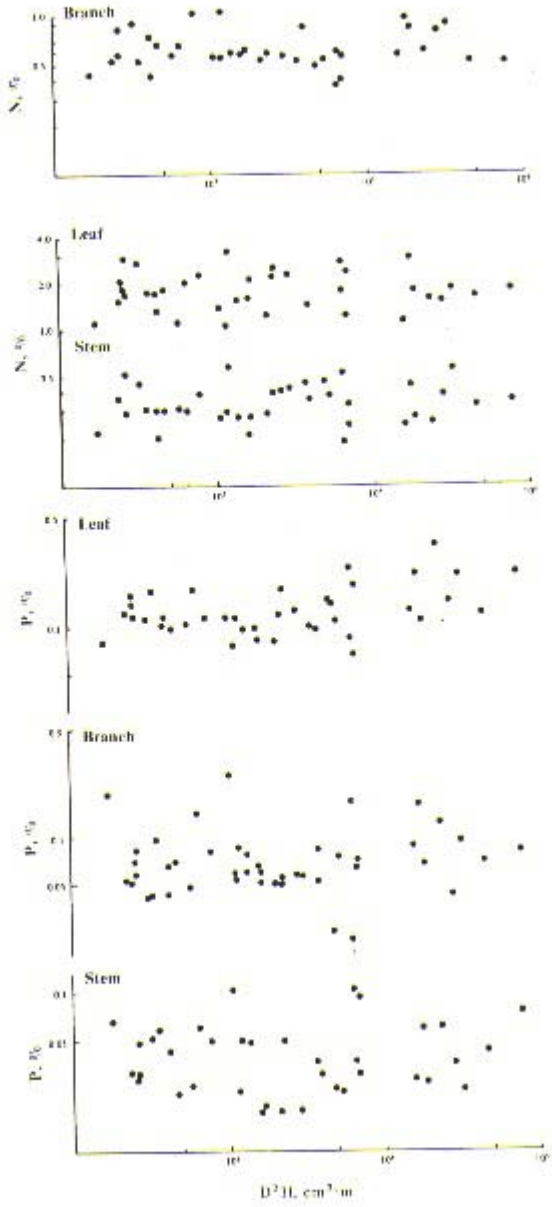

Fig. 1. Relationship between tree size(D^2H) and nitrogen and phosphorus concentrations for each part of sample trees.

2. Species and Nutrient Concentration

Table 2. Nutrient elements concentrations for leaves of *Calophyllum dryobalanoides* (%)

No.	N	P	K	Ca	Mg	D cm	H m
107	2.90	0.16	1.81	1.41	0.85	6.10	7.30
115	2.04	0.17	1.12	1.93	0.44	6.50	8.80
211	1.79	0.10	0.67	2.38	0.59	7.90	7.45
220	2.23	0.11	1.01	3.74	0.93	8.50	10.8
1	2.46	0.17	0.94	1.85	0.50	13.9	12.5

The forest studied was very rich in tree species, and forty sample trees consist of twenty-five species. This means that number of individuals of same species is rather few. There were five individuals of *Calophyllum dryobalanoides* and three of four other species. Table 2 shows the nutrient concentrations of five individuals of *Calophyllum dryobalanoides* for leaves. There are differences in the concentration among same species and same organ.

There would be the differences in concentration between tree species, however the number of individual of same species is rather low to examine the characteristics of tree species. It is hard to conclude that the species characteristics is a major factor affecting the difference of the concentration.

3. Specific Leaf Area and Nutrient Concentration

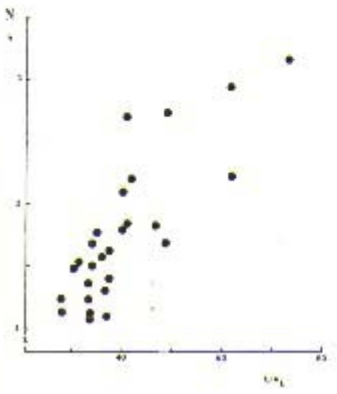

Fig.2. Relationship between specific leaf area (U/W_L) and nitrogen concentration (U.: leaf area, cm^2, W_L: leaf fresh weight, g.)

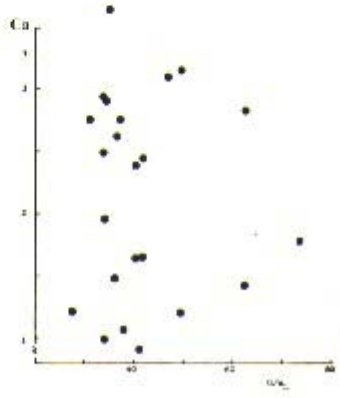

Fig.3. Relationship between specific leaf area (U/W_L) and calcium concentration (U, W_L: same as Fig.2)

It is known that sun leaves are thicker than shade leaves and are usually low in nitrogen concentration. This implies that specific leaf area or thickness of leaf may affect on the nutrient concentration. The specific leaf area of sample trees were measured, and the relationships between them and nutrient concentration were examined. Fig.2 shows that the nitrogen concentration increase with increase of specific leaf area. This means that nitrogen concentration of tree leaves become high with leaves become thin. There were similar relationships to Fig.2 for phosphorus and potassium concentrations, while the fluctuations were rather wide. Calcium is likely to accumulated in cell wall, and it is expected that calcium concentration would become high with thickness, that is the reverse relationship of Fig.2. However, it was hard to conclude that calcium concentration change connected with the specific leaf area, as shown in Fig.3.

It is known that the concentration of nutrients change with season, particularly for leaves. In temperate forest, nitrogen and phosphorus are high in spring and decrease with the progress of maturity of leaves (Tsutsumi 1981). Moreover, they change vertically within the canopy from top to bottom. Therefore, dissimilarity of growth rhythm among individuals might have some effect on the variation of nutrient concentrations among individuals.

Though it is difficult to make clear the reason of the variations in nutrient concentration between individuals, the nutrient concentration of leaves are affected by various factors such as species characteristics, maturity of leaves, specific leaf area and so forth.

Difference of Concentration of Nutrient Element between Organs

It is well known that the nutrient concentrations of leaves are usually higher, followed by branches, and lowest in stems. However, the ratio differ for each element and individual.

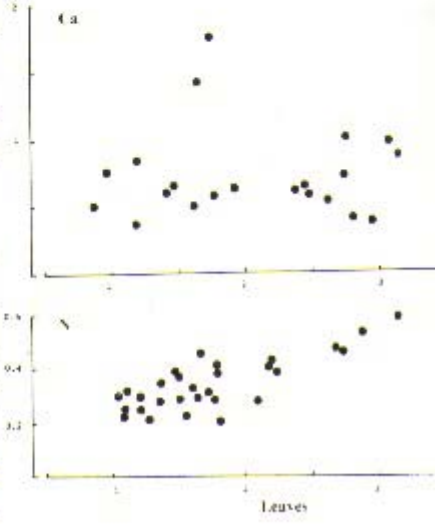

Fig.4. Relationship of concentration between leaves and
stems for nitrogen and calcium.

Table 3. Concentration ratios among organs

	leaves	branches	stems
N	1	0.35	0.19
P	1	0.62	0.36
K	1	0.37	0.18
Ca	1	0.59	0.37
Mg	1	0.35	0.12

Fig.4 shows the relationship between nitrogen concentration of leaves and that of stems. It is likely that nitrogen concentrations in leaves and in stems are positively correlated each other, while for the other elements, such as calcium there were no definite relationships as shown in Fig.4. The ratios based on the average concentrations are shown in Table 3. They were nearly same for nitrogen, potassium and magnesium, and for phosphorus and calcium, respectively. The change of the concentration from leaves to stems was much sharp for the former group than the latter.

Ratio of Concentration between Nutrient Elements

The relationships of concentrations between elements were examined for leaves. Fig.5 shows the relationships between nitrogen and phosphorus, and calcium and magnesium, respectively.

There are the positive relationships for both elements. And it is likely that there was similar relationship between nitrogen and potassium. It seemed that the change of the concentration of one nutrient element connected with the change of the other element. However, there was no clear relationship between nitrogen and calcium or magnesium.

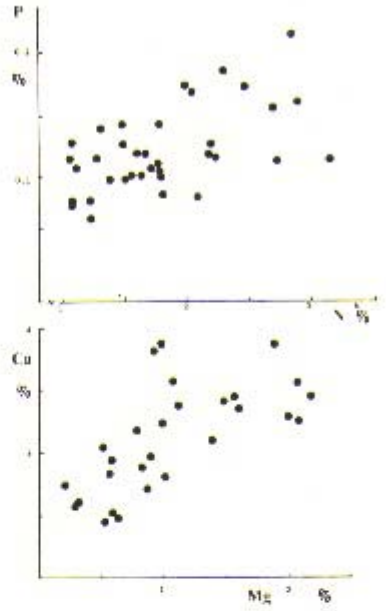

Fig.5. Relationships between nitrogen and phosphorus, and between calcium and magnesium for leaves.

The proportion among elements calculated by the average concentration of leaves was as follows; N:P:K:Ca:Mg was 1:0.07:0.50:1.16:0.51. In this case, calcium was highest, potassium and magnesium were around half of nitrogen and phosphorus was lowest, lower than one tenth of nitrogen in concentration. As mentioned in the previous paper (T. Tsutsumi, et al., 1983), calcium

and magnesium were very high in concentration compared to the other forest, such as evergreen broad leaved forest in Pactongchai (north-east Thailand) and in southern Japan (Tsutsumi, et al., 1967. Tsutsumi, 1977).

It is reported that nutrient concentration of tropical forest trees is rather higher than that of temperate forest (T. Tsutsumi, 1987a). In this case, concentrations of nitrogen, calcium and magnesium were higher than the other types of forest. Particularly, the concentration for stems were higher in this forest. High content of calcium and magnesium might be due to the soil condition where calcium and magnesium were very rich (T. Tsutsumi, et al., 1983). While, high content of nitrogen could be due to the high rate of accumulation of nitrogen in tropical forest (T. Tsutsumi, 1987b).

Accumulation of Nutrient in Tree

The amount of nutrient accumulated in leaves, branches and stems were calculated, and the relationship between biomass and amount of nutrient of individual tree was examined.

Fig.6 shows the above mentioned relationships for nitrogen. There were close correlation between biomass and nutrient accumulated in individual. There were similar relationships for the other nutrient elements, and the following equation was applied.

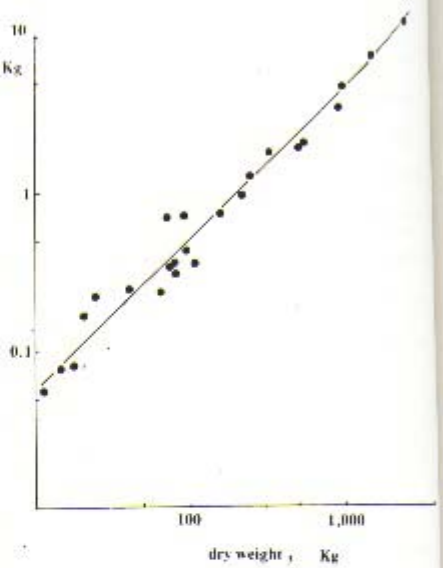

Fig.6. Allometric relationship between nitrogen accumulated and dry weight for individual tree in Nam Phrom Forest

$$\log Ye = a \log w + b$$

Ye ; amount of nutrient accumulated in tree, Kg/individual

W ; dry weight (biomass) of tree, Kg/individual

a, b ; constants

Table 4. Constants of equation for allometry between biomass and mineralmass

	N	P	K	Ca	Mg
a	0.954	0.985	0.945	0.985	0.986
b	−2.208	−3.332	−2.493	−1.993	−2.753

The constants estimated were shown in Table 4. The constants "a" for all of nutrients were nearly 1. This indicate that the mean concentration for individual do not decrease significantly with the increase of biomass. Usually, the proportion of leaves decrease and that of stem increase with increase of biomass. As the result, the mean concentration of individual tree decrease with the increase of biomass. As shown in Fig.7, it seemed that the proportion of leaves decrease with the increase of biomass, however, there was rather wide fluctuation, and the proportion of leaves were low even for some of small tress, probably due to suppression. This would be the reason why the constant "a" was nearly 1, in the present study.

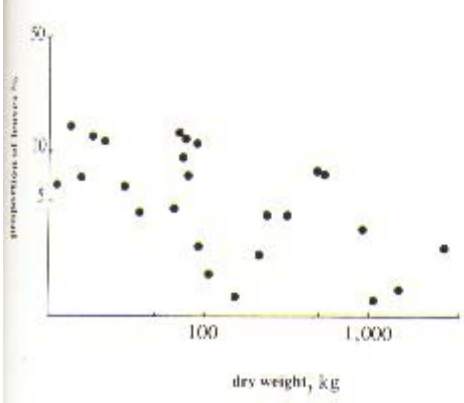

Fig.7. Relationship between proportion of leaves and total dry weight of individual of trees in Nam Phrom Forest

The mean concentration calculated based on Table 4 when tree biomass is 500 kg, were 0.47%, 0.04%, 0.55%, 0.97% and 0.16% for nitrogen, phosphorus, potassium, calcium and magnesium, respectively. Calcium was highest, two times of nitrogen, and followed by potassium and nitrogen. The mean concentrations were nearly same for nitrogen and phosphorus and rather high for potassium, calcium and magnesium compared to the other tropical forest reported by Tsutsumi, et al. 1967, and Edwards, et al. (1982). It can be concluded that calcium and magnesium concentrations of trees in this forest are higher than the other forest.

ACKNOWLEDGEMENT

The cooperative research project on Shifting Cultivation was carried out between Thai and Japanese Scientists, and the forestry group conducted the field studies on the forest vegetation, biomass, productivity, nutrients accumulation and their circulation. The present study is a part of the above studies, and focused mainly on the nutrients accumulation of trees.

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