Research note

Variations of ^{15}N Natural Abundance in Leaves and Soils of Two Natural *Lauro-Fagaceae* Forests in Taiwan

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【Summary】

Foliar and soil δ ^{15}N values of 2 subtroical *Lauro-Fagaceae* forests of Fushan and Liukuei, Taiwan, were investigated to understand N cycling and N use efficiency trends. Although the soils from Fushan (0.67±0.11%) contained less nitrogen than those from Liukuei (1.19±0.05%), there was no significant difference between the average nitrogen contents in foliage (Fushan 1.91±0.18%, Liukuei 1.88±0.32%). The average foliar and soil δ ^{15}N values of Fushan (-1.9±1.3 and 1.6±0.5‰) were both significantly higher than those of Liukuei (-4.4±1.0 and 0.6±0.1‰). This may be due to the higher precipitation at Fushan which could lead to more N losses through leaching of nitrate derived from nitrification and leave the heavier ^{15}N remaining in the system. The δ ^{15}N values of subtropical foliage and soils measured in this study were significantly lower than those reported from tropical forests; however, they did not significantly differ from those of temperate forests.

Key words: stable isotope, δ ^{15}N, subtropical soils, *Lauro-Fagaceae* forest.

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研究簡報

臺灣兩個天然楠櫟林葉片與土壤 ^{15}N 天然豐富度之變異

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摘 要

本研究測定福山與六龜兩個天然楠櫟林葉片與土壤 ^{15}N 天然豐富度之變異，以瞭解亞熱帶森林之氮循環與氮利用效率之趨勢。福山土壤之氮濃度(0.67±0.11%)雖明顯低於六龜(1.19±0.05%)，但兩試驗

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地之葉片平均氮濃度(福山: 1.91±0.18%**、六龜**:1.88±0.32%)**則無顯著差異。福山之葉片與土壤**^{15}N**天然豐富度分別為** -1.9±1.3**及** 1.6±0.5‰ **，均明顯高於六龜之**-4.4±1.0**與**0.6±0.1‰ **，這可能是由於福山之高降雨量，使得在礦化過程中因同位素分離作用而較輕的硝酸根可大量淋溶流失，而留下較重的**^{15}N**所致。本研究中的兩亞熱帶天然楠櫟林葉片與土壤之平均**^{15}N**天然豐富度之測值，均明顯較熱帶森林為低，而與溫帶林者相似。**

關鍵詞：穩定同位素、^{15}N **天然豐富度、亞熱帶土壤、楠櫟林。**

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The ^{15}N natural abundance (δ^{15}N) has been used for interpreting N cycling in forest ecosystems, such as to quantify N fixation in situ (Högberg and Alexander 1995, Kohl and Shearer 1995), or to explore plant uptake of available N sources (Nadelhoffer et al. 1996, Högberg 1997). Although analysis of δ^{15}N in plants and soils for studying the possible mechanisms of N cycling has been investigated in different forest ecosystems, such as tropical rainforests (Vitousek et al. 1989, Roggy et al. 1999), temperate (Martinelli et al. 1999), subarctic (Michelsen et al. 1996) and arctic forests (Kielland et al. 1998), few studies have been conducted in subtropical forests. It was observed that foliar and soil δ^{15}N values decreased when a forest ecosystem changed from “open” to “closed” N cycling (Högberg 1990, Chang and Handley, 2000). As tropical forests are known to have more efficient N cycling than temperate forests (Vitousek and Sanford 1986), the more enriched ^{15}N in tropical than temperate forests provides evidence that N generally functions as an excess nutrient in tropical forests but not in the most temperate forests (Martinelli et al. 1999). In order to gain a fundamental idea about N cycling and N use efficiency trends in subtropical forests, this study investigated the foliar and soil δ^{15}N of two subtropical *Lauro-Fagaceae* forests in Taiwan.

Leaves and soils were collected from 2 subtropical *Lauro-Fagaceae* forests at Fushan (121°43’E; 24°46’N) and Liukuei (120°41’E; 23°55’N), Taiwan. The average annual temperature and precipitation are 18.2℃ and 3,600 mm, respectively, without a clear dry season at Fushan (Hsia and Hwong 1999), and are 17.8℃ and 2,608 mm with a distinct dry season from October to March at Liukuei (Lu et al. 2000). The elevation of the sampling area is 600-700 m at Fushan and 900-1,300 m at Liukuei (Nanfen Shan). The soil type is Hapludults (Ultisols) at Fushan (Lin et al. 1996) and is Typic Dystrochrepts (Inceptisols, USDA soil taxonomy) at Liukuei (Lin et al. 1997). Both soils are very acid (pH_{H2O} 3.8-4.4 at Fushan and 3.4-4.0 at Liukuei) and with low CEC and low base saturation.

Field sampling was done in August 2000 at Liukuei and 2 months later at Fushan. Mature leaves of selected dominant species were collected from at least 3 branches on each tree and were composite into an individual sample. For each species, 2 to 4 individual samples were oven-dried at 65℃ for at least 48 h and pulverized. Soil cores were taken with stainless cylinders (10 cm diameter, 25 cm height, Fushan n=10, Liukuei n=6). Soil cores were then divided into 0-5, 5-10, 10-15, and 15-20 cm. All samples were finely ground for analysis. The nitrogen content was measured using an elemental analyzer (EA NA 1500, Fisons, Rodano, Milan, Italy). The ^{15}N/^{14}N isotope measurements were done in the isotope Lab of the Univ. Goettingen, Germany, with an isotope ratio mass spectrometer (Delta+, Finnigan Mat, Bremen, Germany) coupled to an elemental analyzer (EA 1108, Fisons, Rodano, Milan, Italy) in online mode. The nitrogen stable isotopic composition was expressed in δ(‰) notation:

$$\delta^{15}N = (R_{sample}/R_{standard} - 1)*1000$$

where R is the ratio of $^{15}N/^{14}N$ of sample and standard.

The average foliar $\delta^{15}N$ value in the Fushan area (-1.9±1.3‰, n=15) was significantly higher than that at Liukuei (-4.4±1.0‰, n=16), but no significant difference of the average nitrogen concentrations between Fushan and Liukuei (1.91±0.18 and 1.88±0.32%, respectively) was found (Table 1). This may be due to the higher precipitation at Fushan, which could lead to more N losses through leaching of nitrate and emissions of trace gases derived from nitrification and denitrification and leave the fractionated heavier ^{15}N remaining in the system. Our results show that the subtropical foliar $\delta^{15}N$ values in this study were significantly lower than those from tropical foliage (3.7±3.5‰, n=73); however, they did not significantly differ from those of temperate leaves (-2.8±2.0‰, n=90) measured by Martinelli et al. (1999). Besides, similar to the findings of Martinelli et al. (1999) and Hobbie et al. (2000), leaves with higher nitrogen content tend to be more enriched in ^{15}N (Fig. 1).

The common feature in soil profiles that the soils become more ^{15}N-enriched with depth due to isotopic discrimination during mineralization and vertical transport of ^{15}N-enriched soil organic matter (Wada et al. 1984) was also observed in this study (Fig. 2). Nitrogen concentrations of surface soils at 0-5 cm in our subtropical sites were 0.67±0.11% at Fushan and 1.19±0.05% at Luikuei. These results were between the nitrogen concentrations of tropical and temperate forest soils (0.05 to 0.38% and 1.21 to 1.57%, respectively, Martinelli et al. 1999). Our $\delta^{15}N$‰ values of soils at 0-5 cm, which were 1.6±0.5‰ at Fushan and 0.6±0.1‰ at Liukuei, were also significantly lower than those of tropical forest soils (ranged from 6.4 to 11.2‰, with an average of 8.0‰). But similar to the results for foliar $\delta^{15}N$, the ^{15}N enrichment of soils at 0-5

Table 1. Nitrogen concentration (%) and $\delta^{15}N$ (‰) values of studied plant species

Plant species	Leaf N %	$\delta^{15}N$ ‰
Fushan		
Litsea acuminata	2.00 ± 0.05	-1.3 ± 0.2
Machilus thunbergii	1.69 ± 0.02	-4.0 ± 0.2
Castanopsis carlesii var. *sessilis*	2.09 ± 0.12	-1.4 ± 0.1
Cyclobalanopsis longinux	1.83 ± 0.02	-1.2 ± 0.1
mean	1.91 ± 0.18	-1.9 ± 1.3
Liukuei		
Beischmiedia erythrophloia	1.66 ± 0.08	-4.6 ± 0.1
Neolitsea parvigemma	1.79 ± 0.06	-4.7 ± 0.1
Machilus konishii	1.44 ± 0.03	-6.0 ± 0.2
Pasania hancei var. *ternaticupula*	2.24 ± 0.10	-2.8 ± 0.3
Castanopsis indica	1.96 ± 0.02	-4.0 ± 0.1
Prunus phaeosticta	2.22 ± 0.02	-4.5 ± 0.1
mean	1.88 ± 0.32	-4.4 ± 1.0

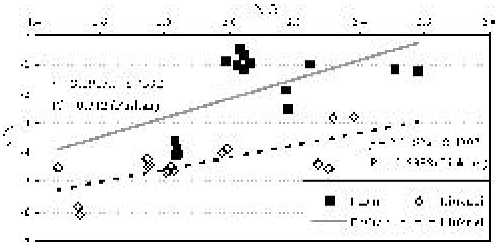

Fig. 1. Relationship between δ^{15}N‰ and nitrogen concentration (%) of foliage samples from Fushan and Liukuei area.

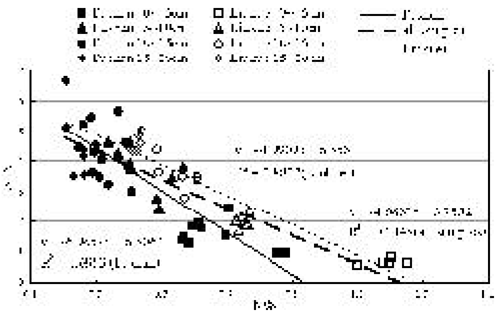

Fig. 2. Relationship between δ^{15}N‰ and nitrogen concentration (%) of soil samples from Fushan and Liukuei area.

cm in this study was in the range of those from temperate forests (-4.0 to 5.5‰, Martinelli et al. 1999).

These results clearly show that the leaves and soils in these two subtropical forests are significantly more depleted in ^{15}N than are those of tropical forests, and the δ^{15}N values in the studied subtropical forests are in the range of those of temperate forests. This may indicate that these two studied subtropical forests may have a more closed N cycle in comparison to most tropical forests (Högberg 1990, Chang and Handley 2000). Further studies on N availability and mineralization rates are necessary for understanding these differences in foliar and soil ^{15}N natural abundance between the Fushan and Liukeui subtropical forests.

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