Litter Decomposition and Nitrogen Release in Three Quercus Species at Temperate Broad-leaved Forest.

Joon Sun Kim*  
Division of Forest Resources and Landscape Architecture, Sunchon National University, 315 Maegok-dong, Suncheon 540-742, Korea  
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Decomposition rates and nitrogen release of leaf litter of Quercus serrata, Q. variabilis and Q. mongolica were studied in temperate broad-leaved forest ecosystem. Freshly senesced leaves were incubated for 300 days and retrieved every 30 days by litter bag method. Main effects for both species and incubating time were highly statistically significant. Mass loss of litters varied significantly among species (P<0.001) and responded differently with the lapse of time (P<0.001). Decomposing litters showed the early slow mass losses during winter and spring but continual rapid mass losses during summer. The decomposition constant(K) was 0.398 for Q. variabilis, 0.340 for Q. mongolica and 0.297 for Q. serrata. The half-life of litter was 1.7 years, 2.0 years and 2.3 years and the time required for decomposition of 95% of the litter was 7.5 years, 8.8 years and 10.1 years, respectively. The Initial N concentration was significantly different among species and tended to increase gradually in all litter types as litter decomposed. The positive correlations between mass loss and C:N ratio revealed that C:N ratio was a good predictor of mass loss of litters. Net N mineralization was occurred as C:N ratio decreased. Q. variabilis showed the immediate and consistent net release of N, and Q. mongolica litter did early immobilization and successive mineralization of N in late decomposition period.  
Key words: litter decomposition, Quercus species, decomposition constant, C:N ratio, nitrogen mineralization

INTRODUCTION

Plant litter deposition and decomposition is an important ecological process of nutrient cycling within forest ecosystems by controlling the amount of nutrients returned to the forest floor and mineral soil. Plant parts such as leaf, twig, branch, bark, flower etc. reach the forest floor as plant litter and release carbon and nutrients by decomposition and mineralization. As forest productivity and development largely depend on the nutrient cycling, litter fall and its decomposition has been investigated for various forest ecosystems.  

Furthermore, litter layer and soil are important pools of carbon sequestration. As litter decomposes, lots of materials which are valuable to forest ecosystem are produced by way of respiration, fragmentation, biological transformation, leaching and weathering (Mackensen and Bauhus, 1999). Some materials take very long time to decompose and have very unique characteristics such as humus. Some of organic carbon is mineralized to CO2 by way of respiration, some accumulates in the forest floor to form humus, and some is transported to deeper soil via soil solution as soluble decay intermediates.  

Decomposition rates are regulated by many biotic and abiotic environmental factors. They include temperature, moisture, microbial activities, soil fauna, substrate quality and so on (Dickinson and Pugh, 1974). Substrate quality is determined largely...
by the tree species and their environments. The decomposition of forest litter is carried out by microorganisms of forest soils, the activities of which in turn are influenced by litter quality. Thus, substrate quality such as chemical composition and physical structure of the litter has been considered one of major critical factors affecting decomposition rate and nutrients release of forest litter. Initial nitrogen content, ratio of carbon to nitrogen, lignin content and ratio of lignin to nitrogen are often considered to be useful indicators to predict decomposition rate (Edmonds, 1980; Taylor et al., 1989b).

Quercus species are dominant tree species in natural temperate broad-leaved forest in Korea. In spite of several studies on decomposition of Quercus species leaves (Chang and Chung, 1986; Kim et al., 2003; Lee et al., 2004), comparative studies on decomposition rate and nitrogen dynamics of Quercus species are needed. The objectives of this study were to compare litter decomposition rate of Quercus serrata, Q. variabilis and Q. mongolica and to determine nitrogen dynamics in decomposing litter under the same environment at temperate broad-leaved forest in Mt. Baekun, Jeonnam.

MATERIALS AND METHODS

Site description

The research was carried out on a site located on southwestern hillside at an elevation of 700 m above the sea level in Mt. Baekun, Gwangyang, Jeonnam. The research site comprised temperate mixed deciduous forest; Quercus serrata was a dominant tree species and Carpinus laxiflora was a co-dominant. Moreover, Styrax japonica and Lindera erythrocarpa were abundant in sub-canopy layer, and so was Rhododendron schlippenbachii in shrub layer. Soils on the study sites were classified in the Haengsan-Mudeung-Cheongsan series as loam or sandy loam.

Litter collection, experimental design and sampling of incubated litter

Freshly senesced leaves of Q. serrata, Q. variabilis and Q. mongolica were collected from the floor of the study site and surrounding forest floors in late October, 2005. Leaf litter samples were carried to a laboratory and air-dried at room temperature in the shade. Litter decomposition rates were determined in the field by using litter bag method. Six gram of air dried litter of each species was weighed to the nearest 0.01 g and put into litter bag. Dry weight was measured on 3 sub-samples of each single litter type after drying at 65°C for 48 hr. to determine the correction factor between air-dry mass and oven-dry mass. The litter bag (15 x 30 cm) was made of polyethylene mesh with 6mm holes on the upper side and 1 mm meshes in the lower side (Kelly and Beauchamp, 1987). This mesh size could minimize the loss of small litter particles and allowed migration of small detrivores.

On December 5, 2005, a total of 72 litter bags, 24 litter bags for each species, were placed on the floor of the study site. Three 4 x 4 m plots were placed on the forest floor and 8 samples of each litter type were placed in each plot and anchored to soil with aluminum pins. Samples of 3 litter types were incubated for 300 days. The outset of litter retrieval was carried out in 90 days of incubation. A sample per species was retrieved randomly from each plot at 30 days intervals. The retrieved litter samples were cleaned of soil material, oven-dried to constant weight at 65°C for 48 hr., and then weighed to determine dry mass loss. Litter samples of each species at each retrieval were pooled and ground to pass 1 mm mesh screen for chemical analysis. The carbon(C) and nitrogen(N) concentrations were analysed for 3 replicates using kjeldahl digestion and dry ashing method.

Mass loss determination and statistical analysis

Mass loss through time was estimated by least square regression on the natural logarithm of % mass remaining over time. One way ANOVA on litter mass remaining during experiment was used to compare the differences among species and litter retrieval time. All regression slopes were tested using the F statistics. The annual decomposition constant(k) was calculated using single exponential decay model (Olson, 1963):

$$X_t = X_0 e^{-kt}$$

where $t$ is the time in year, $X_0$ is the initial amount of litter, $X_t$ is the remaining amount of litter after time $t$ and k is decomposition constant. One way ANOVA was used to compared the decomposition rate, i.e. the slopes of linear exponential equations ($ln(X_t/X_0)$ vs. time). Duncan’s new multiple range test was used to test the differences among species. Half time (50%) and 95% time for environmental decay were