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LITTER DECOMPOSITION OF MIXED COMMUNITY FOREST TREE SPECIES OF GARHWAL HIMALAYA, INDIA

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Abstract-Litter decomposition of tree species like *Alnus nepalensis*, *Lyonia ovalifolia*, *Myrica esculenta, Pyrus pashia* and *Rhododendron arboreum* was studied in a Parkandi village landscape, Garhwal Himalaya. Initial nutrient concentration of litter was estimated. Carbon content varied from 44.45-48.34%, lignin from 15.3-28.23%, cellulose from 31.4-46%, N from 0.69-2.93%, P from 0.021-0.072%, K from 0.73-2.93% across species. Carbon concentration seemed the most stable/least variable chemical attribute. N fixing *A. nepalensis* had the highest concentration of N but not of P while *R. arboreum* had the highest concentration of K. Annual decomposition constant varied from about 1 in *A. nepalensis* and *P. pashia*, 0.5 in case of *M. esculenta* and *R. arboreum*. Though *A. nepalensis* had higher concentration of N and lower concentration of lignin compared to *P. pashia*, the two species had almost similar half-life (0.7 years) suggesting the importance of attributes other than chemical characteristics in determination of decomposition rate.
Key words: litter decomposition, annual decomposition constant, decomposition rate, litter quality

Introduction

Decomposition and photosynthesis are processes that account for the majority of the biological carbon processing on planet earth. Decomposition of organic matter is responsible for the formation of humic substances that contribute to soil fertility as well as the long term storage of carbon. Decomposition is closely tied to nutrient cycling and is essential for the regeneration of organically bound nutrients. Litter decomposition is influenced by climatic factors, litter quality, decomposer organisms present in the soil. The influence of climatic factors such as mean annual temperature, mean annual precipitation and annual actual evapotranspiration [1-6]. Effect of litter quality, such as nitrogen content (N) [7], carbon:nitrogen ratio (C:N) [8], lignin content [9], and lignin:N ratio [1, 10, 11], vegetation and litter types [12-13] and anthropogenic disturbances [14] on litter decomposition have been reported.

Decomposition begins with complex plant detritus and produces carbon gases and humus. The process can be characterized by the rate of mass loss and the rates of nutrient immobilization and release. In addition, the chemical composition of decaying litter changes during decomposition. These changes are neither in all cases, linearly associated with mass loss, nor the changes in composition the same for similar litter substrates decomposing under different environmental conditions. Thus, there is a complex and interacting set of factors that regulate mass loss, humus formation, nutrient dynamics and patterns of change in chemical composition of decomposing plant litter. The objective of the present study was to evaluate nutrient characterization of leaf litter and litter decomposition of a community forest trees.

Methodology

Study area

The Garhwal Himalaya, spread over a geographical area of 29698 km^2 comprises five districts of Uttaranchal state of India viz. Uttarkashi, Chamoli, Pauri, Tehri and Dehradun. The study was carried out in and around the Chamali village landscape in Chamoli district (30º 27^1 N latitude and 79º 5^1 E longitude). The landscape covers an elevation range of 800-1400 m above mean sea level (amsl). The year consists of three seasons: dry summer season (April-June), warm rainy season (July-September), and winter season (October-March). Annual average rainfall is about 1200 mm and about 80% of total rainfall is received during rainy season. The parent material is represented by feldspathic quartz schists, quartz muscovite schists and quartz chlorite schists, and can be classified as Dystric cambisol according to FAO soil classification system.

Litter characterization and decomposition study

Mature senesced leaves were collected separately from each tree species of *A. nepalensis, L. ovalifolia, M. esculenta, P. pashia* and *R. arboreum* in the month of June, 2006. Leaves were air dried and used for estimation of nutrients and litter decomposition. Carbon (%) was estimated by ash-free weight method [15], lignin (%) and cellulose (%) was estimated by acid detergent

fibre method [16]. Nitrogen (%) was estimated following Kjeldhal oxidation method, Phosphorus (%) was estimated by ascorbic acid method and Potassium (%) was estimated using atomic absorption spectrophotometer method [15]. For litter decomposition, mass loss was estimated following 'litterbag' method [17]. Decomposition constant was calculated following [18]:

$$k = \ln(x_0/x_t)/t$$

where x_0 is the original biomass or nutrient content of litter, x_t is the mass or nutrient content remaining after time t (in years). Half lives ($t_{0.5}$) of decomposing litter samples are estimated from the *k*-values as follows [19].

$$t_{0.5} = \frac{0.693}{k}$$

The characteristics and decomposition constant variations between tree species were determined by one-way ANOVA and differences between treatments were evaluated with a Tukey-test [20].

Results and Discussion

Litter quality

The chemical characteristics of leaf litter like C, N, P, lignin observed in the present study are within the reported range of values reported by Semwal *et al.* [21] in mixed plantation, Garhwal Himalaya and by Singh *et al.* [22] in native tree plantation in Madhya Pradesh, India, but lower than the values reported for evergreen and deciduous tree species of California [23] and high altitude Maple forest [24]. The highest concentration of carbon was recorded in *M. esculenta* (48.34%) and least concentration in *A. nepalensis* (44.45%). The highest concentration of lignin and cellulose was recorded in *R. arboreum* and least concentration in *A. nepalensis*.

The highest concentration of nitrogen was recorded in *A. nepalensis* (2.39%) followed by *P. pashia* (1.53%), *M. esculenta* (1.43%), *L. ovalifolia* (0.8%) and *R. arboreum* (0.73%). *A. nepalensis* is non-leguminous and nitrogen fixing tree species recorded highest nitrogen concentration compared with other species (Table 1).

Mass loss and annual decomposition constants

Ewel [25], Xuluc-Tolosa *et al*. [26] and Semwal *et al*. [21] reported faster and Mesquita *et al*. [27] and Vasconcelos and Laurance [28] slower decomposition rates of pioneer trees compared to mature forest species. Thick lignified leaves with prominent veins and midribs decompose slowly when compared with less lignified tissue [29]. In this study, leaf litter leaf litter of *A. nepalensis* and *P. pashia* decomposed faster compared to *L. ovalifolia, M. esculenta* and *R. arboreum*. The former tree species had high nitrogen and phosphorous content which showed highest decomposition rates. Similar trend was observed by Godshalk and Wetzel [30] and Lee and Bukaveckas [31]. *R. arboretum, M. esculenta* and *L. ovalifolia* showed higher lignin, C:N ratio and Lignin:N ratio and observed to be slow decomposing tree species compared to *A. nepalensis* and *P. pashia*. Litter quality parameters are important in determining the litter decomposition rates (Fig. 1). Therefore nutrient composition seems to be the most influential factor in determining the rate of decomposition [32-35].

Several studies have revealed that plant materials with N > 1.7%, lignin <15% and C/N ratio < 20 generally mineralize while those exceeding these limits immobilize N [36-39]. Thus the assessment of C:N and lignin:N ratio serves as a good indicator of litter quality [21]. Assuming the applicability of these results to the present study, of the 5 tree species selected only *A. nepalensis* leaf litter will release nutrients immediately when applied in agricultural ecosystem. Time-course study of leaf litter mass remaining indicated widely varying decomposition rates in these tree species (Table 2). *P. pashia* (1.03) exhibited the highest decomposition constant followed by *A. nepalensis* (0.99), *L. ovalifolia* (0.67), *M. esculenta* (0.56) and *R. arboreum* (0.53). In tropical forests, *k* values are often greater than 1.0 indicating that complete leaf litter turnover occurs in a year or less than a year [40]. The value obtained for *P. pashia* in this study was >1, while other species had a value of decomposition constant <1.

Conclusion

Litter quality varied with tree species in village community forest of Garhwal Hiamalya. Litter characteristics are important in maintaining the litter decomposition rate. Annual decomposition constant varied from about 1 in *A. nepalensis* and *P. pashia*, 0.5 in case of *M. esculenta* and *R. arboreum*. Though *A. nepalensis* had higher concentration of N and lower concentration of lignin compared to *P. pashia*, the two species had almost similar half-life (0.7 years) suggesting the importance of attributes other than chemical characteristics in determination of decomposition rate. Varied litter decomposition rates of tree species in the community forest is advantageous over long term soil fertility maintenance in the agriculture lands when leaf litter supplemented to agriculture crops of Garhwal Himalaya.

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Table 1-Characteristics (mean ± standard deviation) of leaf litter of different tree species in mixed forest, Parkandi village, Garhwal Himalaya.

Characteristics	*A. nepalensis*	*L. ovalifolia*	*M. esculenta*	*P. pashia*	*R. arboreum*	*F*-value
Carbon (%)	44.45 ± 0.41 d	48.10 ± 0.04 ab	48.34 ± 0.11 a	45.23 ± 0.35 c	47.53 ± 0.13 b	144.4***
Lignin (%)	15.23 ± 0.35 e	22.97 ± 0.21 c	25.07 ± 0.35 b	21.20 ± 0.36 d	28.23 ± 1.05 a	231.8***
Cellulose (%)	31.40 ± 0.66 d	38.40 ± 0.78 c	42.03 ± 0.40 b	38.13 ± 0.31 c	46.03 ± 0.83 a	221.1***
Nitrogen (%)	2.39 ± 0.13 a	0.80 ± 0.10 c	1.43 ± 0.03 b	1.53 ± 0.03 b	0.73 ± 0.03 c	218.6***
Phosphorus (%)	0.072 ± 0.005 a	0.047 ± 0.006 b	0.051 ± 0.006 b	0.065 ± 0.004 ab	0.021 ± 0.002 c	30.6***
Potassium (%)	0.73 ± 0.03 d	2.23 ± 0.11 b	1.92 ± 0.04 c	0.69 ± 0.08 d	2.53 ± 0.03 a	502.4***
C/N ratio	18.7 ± 1.2 c	60.8 ± 7.7 a	33.7 ± 0.8 b	29.5 ± 0.4 b	64.9 ± 3.0 a	88.2***
Lignin/N ratio	6.39 ± 0.45 d	28.99 ± 3.41 b	17.50 ± 0.58 c	13.83 ± 0.53 c	38.57 ± 2.69 a	124.0***
F-values from one-way analysis of variance (ANOVA) denote significant level: ***P<0.001. Values followed by different letters within a row differ significantly in Tukey-test (P<0.05).						

Table 2- Annual decomposition constant (k), $t_{0.5}$ (half life) and R^2 (for singly exponential decay model) of leaf litter of different tree species in mixed forest in Parkandi village, Garhwal Himalaya

Decomposition Characteristics	*A. nepalensis*	*L. ovalifolia*	*M. esculenta*	*P. pashia*	*R. arboreum*	F-value
K	0.99 ± 0.03b	0.67 ± 0.01c	0.56 ± 0.01d	1.03 ± 0.01a	0.53 ± 0.02e	835.3***
$T_{0.5}$	0.70 ± 0.02d	1.04 ± 0.02c	1.23 ± 0.02b	0.68 ± 0.01d	1.31 ± 0.04a	810.0***
R^2	0.96	0.93	0.93	0.95	0.97	-
F-values from one-way analysis of variance (ANOVA) denote significant level: ***P<0.001. Values followed by different letters within a row differ significantly in Tukey-test (P<0.05).						

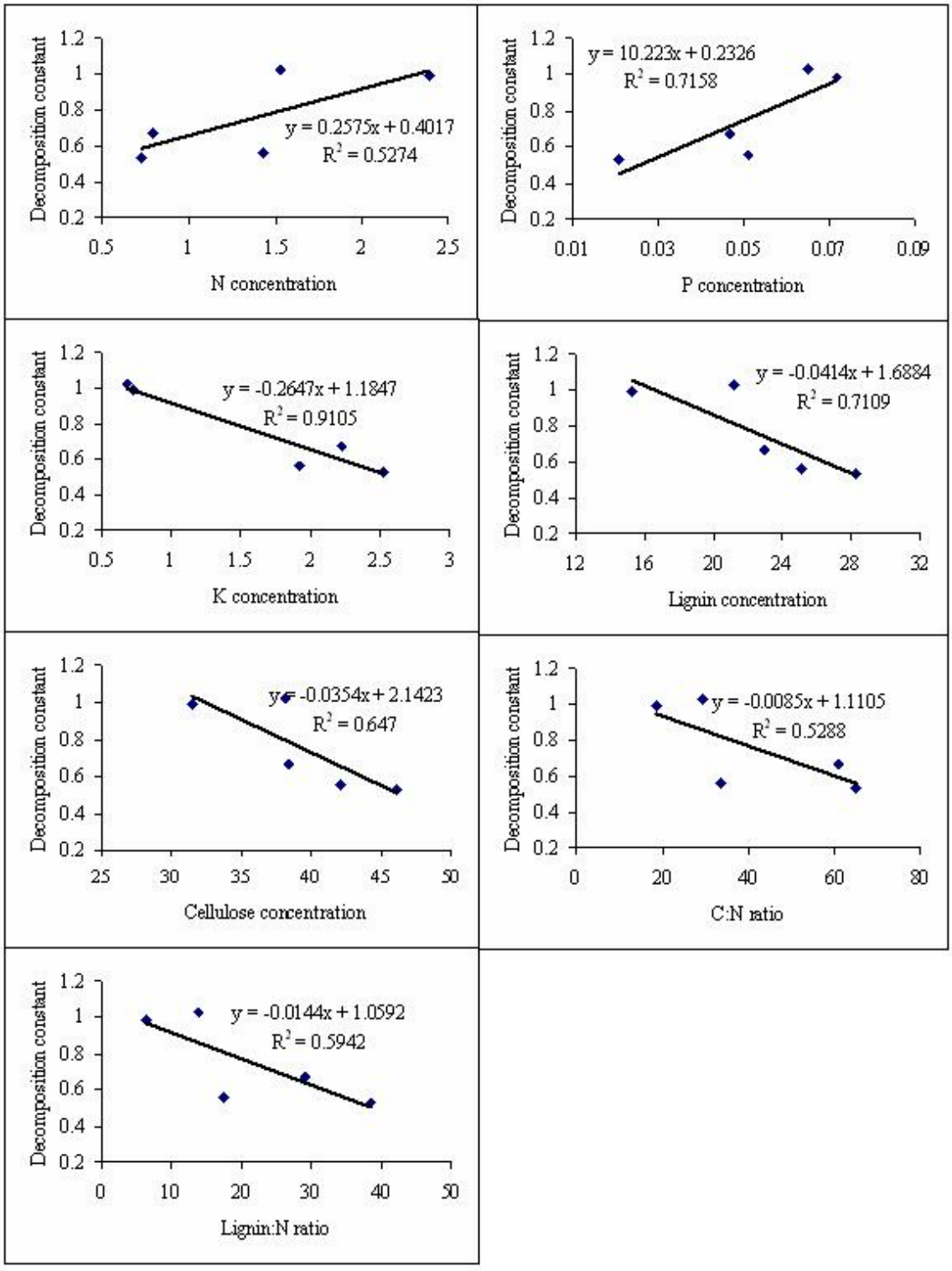

Fig. 1-Regression of leaf litter quality parameters and annual decomposition constants (k) in tree species in mixed forest at Parkandi village, Garhwal Himalaya.