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Leaf Litter Decomposition of Two Central Himalayan Oaks

KIRTIKA PADALIA*, RAJENDRA SINGH PARIHAAR, NIDHI BHAKUNI and BHAWANA KAPKOTI

Department of Botany, DSB Campus, Kumaun University, Nainital-263002, India.

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ABSTRACT

The study was conducted in two natural oak forest of Nainital (Uttarakhand) India, during 2012-2013 to determine the weight loss pattern in leaf litter of two Central Himalayan Oaks (i.e., *Quercus leucotrichophora* A. Camus. and *Quercus floribunda* Lindl.) with the help of litter bag technique. The present study concluded that weight loss proceeded throughout the study period and relatively higher within 60 days after the placement of litter bags into the soil. Among these two species, higher weight loss observed in *Q. floribunda* as compared to *Q. leucotrichophora* across both the sites. Within 365 days, average weight loss observed about 60% in *Q. leucotrichophora* and 62% in *Q. floribunda.* Decay rate coefficient rate ranged from 0.0596- 0.0014 for *Q. leucotrichophora* while it varies from 0.0558 to 0.0013 for *Q. floribunda.* The monthly relative decomposition rate (RDR) ranged between 0.0598-0.0014 g/g/day and 0.0208-0.0050 g/g/day for *Q. leucotrichophora* and *Q. floribunda*, respectively. Climatic factors (rainfall, temperature and relative humidity) also influenced the rate of decomposition.

Key words: Litter decomposition, Oak forest, climatic factors, weight remaining, weight loss.

INTRODUCTION

Decomposition refers to a biological process in which organically bound nutrients released in the form of free ions into the soil solution. Plants take up these nutrients from the soil, use them for metabolic process and return the nutrients through litter fall. Litter decomposition influence the nutrient dynamics of an ecosystem and serve as one of the input of nutrients in the forest ecosystem. It is estimated in a study that about 69-87% of the total annual requirement of essential elements in forest plants is fulfilled by the litter decomposition. Therefore, litter decomposition contributes a significant role in the nutrient budgeting of forest as well as in agroecosystem where vegetation depends primarily on the recycling of plant detritus for nutrients requirment[1]. Physical factors (temperature and soil moisture etc) influence the rate of decomposition significantly. The process of decomposition slows down or nearly restricted in a very dry soil due to the low population of microbes (because the fungi and bacteria dry out).

Other than this, the food source (i.e. decomposing leaves) of microbial decomposers is one of the controlling factor which influence the rate of decomposition [2,3], basically nutrient-rich leaves (high quality leaves: alder) decomposed faster than nutrient deficit leaves(low quality leaves: conifer needle). Decomposition process plays an important role in soil fertility in terms of nutrient cycling and formation of soil organic matter[4,5,6]. Other than this, litter cover also act as a protective layer by buffering changes in soil water content[7], temperature[8], hindering erosion[9] and soil compaction[10].

Oak species presume significant conservation in the Himalayan region as provided numerous ecosystem services[11,12]. Oaks, particularly

Q. leucotrichophora and *Q. floribunda* associated not only with agro-ecosystems but serve as the life support systems of inhabitants in hills of the Himalaya[13,14]. Oak forests are the source of fuel, timber and can be interrelated with natural springs and wildlife[14,15]. In view of this, as oak is a key stone species and serve as the multipurpose tree in the Central Himalayan forest, present study was carried out with the major objectives (i) to evaluate the weight loss pattern of decomposing leaf litter of two Himalayan Oak species (i.e. *Q. leucotrichophora* A. Camus.ex Bohadur and *Q. floribunda* Lindl. ex Rehder) and (ii) to correlate weight loss pattern with different parameters.

MATERIALS AND METHODS

Study site, climate and soil

The present study conducted in Nainital (29°23'N 79°27'E29.38°N 79.45°E) at an altitude of 2,084 m (6,837 ft) asl. Study area was dominated by natural oak forest as in the Indian Central Himalaya, generally one and two species of oak dominated forest, hence dominant types are easily recognizable[16]. These are *Q. leucotrichophora* forest which covers extensive areas in lower elevation (1,000-2100 m), *Q. floribunda* forest are distributed in the limited areas between 1,800-2,400 m.

The site is further divided into two sub sites; the first site situated near to Botany department in DSB Campus (altitude 2,084 m), Nainital, considered as site-1, dominated with *Quercus leucotricophora* A. Camus., *Quercus floribunda Lindl., Cedrus deodara* (Roxb. ex D. Don) G. Don, *Acer oblongum* Wall., *Cornus capitala* wall. and *Prunus ceresoides* D. Don while the other site-2 was at the forest of Kailakhan (altitude 1800-1950 m) (Nainital) and was dominated with *Quercus leucotricophora* A. Camus., *Quercus floribunda Lindl., Cedrus deodara* (Roxb. ex D. Don) G. Don, *Lyonia ovalifolia* (Wallichi.) Drude, *Myrica esculenta* Buch.-Ham., *Cupressus torulosa* D. Don and *Rhododendron arboreum* Smith.

Climate is monsoonal temperate and characterized by discernible seasonality. The whole year can be divided into three marked seasons: summer (Mid-March-mid June), rainy (mid June-September) and winter (November-February). October compose the intermediary between rainy and winter seasons. Average maximum temperature fluctuated between 15°C in January to 27°C in May and mean monthly minimum from 2°C in January to 15°C in June. Total rainfall was about 2315 mm of which nearly 83% occurs during rainy season from monsoon. Mean monthly relative humidity ranged from 92% and was maximum in September and minimum in December. The months of June to September constitute for the yearly showers and from December to February Nainital engulfed by snow. Meteorological data of the study year is given in figure 1.

Soil of the study sites was black in color, loam in texture, moderate in nutrients and slightly acidic in nature. The average soil temperature of the site was 15°C-17°C in summer and in winter it varies from 5°C to 8°C.

Experimental design

Characteristics of experimental leaf

All the Himalayan oaks are evergreen with lifespan of about one year, sclerophyllous with specific leaf mass exceeding 130 g/m^2 and their size class varies from microphyll to misophyll [17]. Among the Himalayan oaks, the leaf of *Q. floribunda* has spinose leaves having green on both dorsal and ventral surface while *Q. leucotrichophora* have dentate margin in the upper half and entire in the lower half, contain silvery white colour in the ventral surface[18]. The colour of the leaves also changed with the age, for example, the leaves of *Q. leucotrichophora* appears reddish brown when young and turn green when mature. In contrast, the young leaves of *Q. floribunda* do not contain any extra coloured pigments other than the chlorophyll. The young leaf of *Q. leucotrichophora* has a thick wax layer to check the transpiration because stomata control is not yet developed[17].

Experimental setup

First of all, mature, nearly senesced but attached leaves of *Q. leucotrichophora* and *Q. floribunda* from the study site were collected after the leaf fall and brought to the laboratory. Flatten the leaves in newspaper and dry them in at room temperature for 24-48 hours. Litter bag (Nylon litter bags) technique was used to measure decomposition rates. Litter bags were prepared having the size of 20 x 20 cm with 1 mm mesh size in order to minimize

artificial litter loss from the bags. 10 gm (initial weight) of air dried leaf of each species were kept in litter bag, separately. Mesh size of 1 mm was sufficient to permit movement of micro-organisms, which are the predominant litter feeders[19]. Oven drying method was used to determine the moisture content of the litter. A total of 36 litter bags (3 sub-sample bags for a month) for each species were placed in each forest site. Litters bags were buried into the soil separately for each species in such a way that bags were kept in contact with soil and not to be disturbed as much as possible.

Three litter bags of each species recovered randomly at every 30 days intervals for 12 months at each location. Rebuff all external impurities and slide the sample bags into a separate bag for bring back to the laboratory. The recovered residual materials were washed carefully with tap water to remove all adhere surface impurities and also the soil particles, then dried the residual at 60°C-80 °C in oven to constant and weighed.

Calculation

The decomposition rate computed through the 6 replicates (3 replicate for each site) of each species. The average value was used for the further analysis.

Litter mass loss and decay rate coefficient

Litter mass loss was expressed as the % remaining after in a given time and was calculated as: $\%R = W(t_x) / W(t_i) \times 100$

Where $W(t_x)$ is the dry weight (g) of the leaf material remaining after time (t_x), and $W(t_i)$ is the initial weight (Peterson)[20].

Decay rate coefficient (k) was calculated as:

$$-k = \ln(\%R/100)/t$$

Where, t is the time in days (Peterson)[20].

Relative decomposition rate (RDR) was computed by using the formula

$$RDR\ (g/g/day) = \ln(W_1 - W_0)/t_1 - t_0$$

Where, W_0= mass of litter present at time t_0; W_1= mass of litter present at time t_1; t_1-t_0 = sampling intervals (days).

RESULTS AND DISCUSSION

Weight loss pattern

Loss of dry matter in decomposition was measured at monthly interval during one year (July 2012-June 2013) of the study period. *Q. leucotrichophora* had shown an average of 60.15% weight loss within 365 days on both the sites. The maximum (16.7% of the original litter mass) decomposition of the litter has been observed after the first month of the study period and the minimum was observed in the month of December-January (1.85%). The relationship between days elapsed and % weight loss for this species is given in figure 2.

During entire course of study, the average rate of litter decomposition in *Q. leucotrichophora* was obtained 60.15% at both the sites. Decomposition

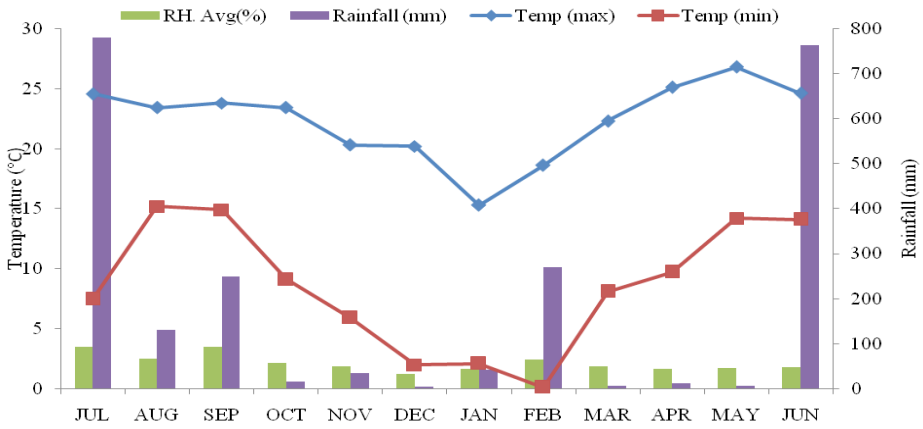

Fig. 1: Meteorological data during the study period (2012-2013) (Source: ARIES, Nainital)

Table 1: Comparative study of leaf litter decomposition in oak and other plant species

SN	Species	Forest type, region	Period of study (days)	% of weight loss	Decay rate coefficient (range)	References
1	*Q. leucotrichophora* *Q. floribunda*	Oak forest, Central Himalaya	360	60.15 61.95		Present Study
2	*Q. leucotrichophora, P .roxburghii*	Oak Pine mixed forest, Central Himalaya	365	65-100	-	(Usman, 2013)[24]
3	*Q. leucotrichophora*	Oak forest of Kumaun Himalaya	365	67.55	-	(Kumar and Tewari, 2014)[25]
4	Oak	Himalayan Oak forest	365	80.45	-	(Singh and Singh, 1984)[26]
5	*Q. leucotrichophora* *A. indica. C. deodara, C. torulosa, D. cannabina, I. dipyrena, Q.leucotrichophora.*	Oak conifer forest	510	96 72-100	- -	(Pandey and Singh, 1982)[27]
6	*C. nepalensis*	Oak Mixed forest, Central Himalaya	210	87.80	0.009-0.028	(Bargali et al, 2015)[28]
7	*S. robusta, M. indica,* *D. melanoxylon, S. oleosa*	Tropical dry deciduous forest, Chhattisgarh, Central India	332	87.9-95.7	0.21-0.28	(Bargali et al, 2015)[1]
8	Six-year-old plantations of *E. tereticornis, D. sissoo, S. grandiflora* and *L. leucocephala*	Agriculture farm of Pusa, Subtropical region	365	85.2-100	0.0040-0.0285	(Das and Chaturvedi, 2003)[29]
9	*Eucalyptus* sp	1-8 year eucalypt plantation	480	95-98	-	(Bargali et al, 1993)[6]
10	*L. leucaena*	Agriculture farm of of IGAU, Raipur (Chhattisgarh), Central India	212	100	-	(Pandey et al, 2006)[30]
11	*D. tuberculatus*, *D. retusus*	South bank tropical wet evergreen *D. retusus* forest in Arunachal Pradesh, tropical deciduous forest in Manipur	450	99.6-99.8	0.16-0.22	(Kumar et al, 2012)[31]

rate of leaf litter gradually decreased with the increase of time. As the time move on the process of decomposition was also slow down at both the sites. The statement is supported by a study proclaimed that two phases recognized in the process of decomposition: Decomposition during the first phase proceed rapidly because molecules of starch and amino acids easily break down and transfer the more soluble compounds to the soil as C and N which progressively mineralized or immobilized while the second stage follow relatively slower because humification of lignin and cellulose is complex and time taking[21].

The weight loss pattern of *Q. floribunda* leaf litter showed 61.95% disappearance during the entire study period. This species showed the maximum weight loss (35.80%) in rainy season and minimum in winter season (10.7%). The relationship between days elapsed and % weight loss for this species as given in the figure 3. In the first month of decomposition the litter was about 19%, as the time move on, the process of the decomposition also slow down. Within the six months, the weight loss was 44%. A Comparative study of leaf litter decomposition in oak and other plant species is given in the table 1.

Table 2: Decay rate coefficient (k) and Relative decomposition rate (g/g/d) of oak species

Day elapsed	*Q. leucotrichophora*		*Q. floribunda*	
	k (day^{-1})	RDR (g/g/d)	k (day^{-1})	RDR (g/g/d)
30	0.0597	0.0171	0.0559	0.0209
60	0.0225	0.0159	0.0194	0.0190
90	0.0124	0.0132	0.0114	0.0142
120	0.0081	0.0111	0.0080	0.0112
150	0.0060	0.0094	0.0058	0.0096
180	0.0046	0.0082	0.0046	0.0099
210	0.0037	0.0073	0.0037	0.0072
240	0.0031	0.0065	0.0031	0.0065
270	0.0024	0.0061	0.0024	0.0062
300	0.0020	0.0057	0.0020	0.0057
330	0.0017	0.0053	0.0016	0.0054
360	0.0014	0.0050	0.0013	0.0051

Table 3: Pearson correlation between decomposition rate and different parameters

	D	LR	R	T	RF	RH
D	1					
LR	-967**	1				
R	0.967**	-1**	1			
T	0.047	-0.23	0.023	1		
RF	-1	0.24	-0.24	0.224	1	
RH	-660**	0.702**	-0.702	0.285*	0.520**	1

** Correlation is significant at the 0.01 level and * at the 0.05 level, D= days, LR= litter remaining, R=weight loss, T= temperature, RF= rainfall, RH= relative humidity

The decay rate coefficient and relative decomposition rate for both species of oak is given in the table 2. Decay rate coefficient rate ranged from 0.0596- 0.0014 for *Q. leucotrichophora* while it varies from 0.0558 to 0.0013 for *Q. floribunda*. The monthly relative decomposition rate (RDR) ranged between 0.0598-0.0014 g/g/day and 0.0208-0.0050 g/g/day for *Q. leucotrichophora* and *Q. floribunda*, respectively. The decomposition rate was greater during the rainy season, possibly due to the pronounced activities of microbes under the favorable conditions of temperature, moisture and rainfall[22]. Several studies shown highest disappearance rate of 36-53% during rainy season and15-26% in winter[23]. The Correlation between decomposition rate and different parameters is given in table 3and showed negative correlation with the days elapsed and significant positive correlation with the rainfall and the soil temperature.

CONCLUSIONS

This study concluded that the weight loss continued throughout the study period and relatively higher weight loss occurred within 60 days after the placement of litter bags. The rate of decomposition at monthly interval showed the different pattern for the different species. Among these two species, higher weight loss observed in *Q. floribunda* as compared to *Q. leucotrichophora* across both the sites. It was also concluded that the rate of decomposition also influenced by the physical factors and climatic conditions. Comparatively faster weight loss occurred during the rainy season (33-36%) while reached in its minimum during winter (11-9%).

Further, the natural forests are enrich in diversity of litter and the litter of many species

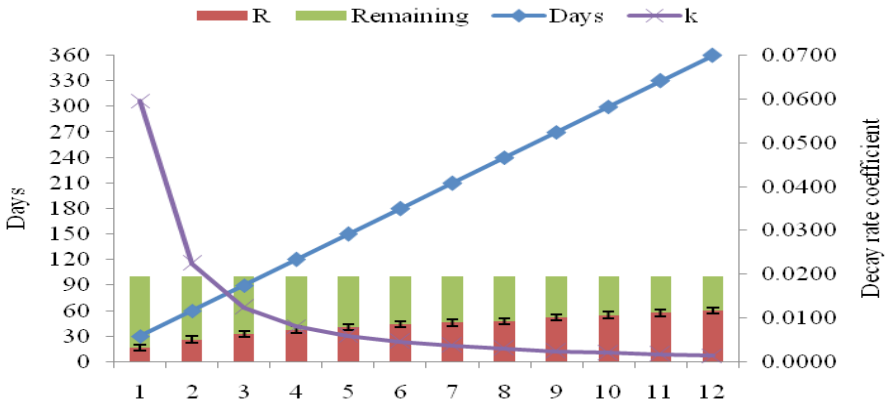

Fig. 2: Leaf litter decomposition pattern in *Q. leucotrichophora*

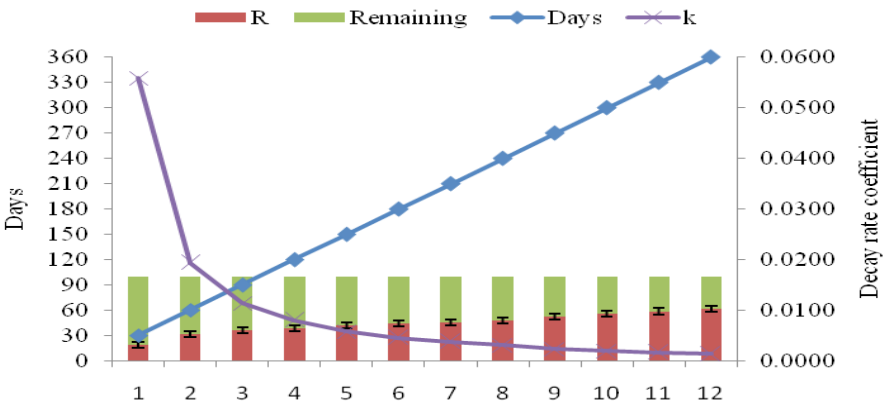

Fig. 3: Leaf litter decomposition pattern in *Q. floribunda*

intermingled with each other on the ground in natural way. So a detail study is needed to know the decomposition rate of all those species and their role in soil fertility to determine the nutrient dynamics in the forest.

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