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Full Length Research Paper

Pattern of litter fall and litter decomposition in a *Quercus leucotrichophora* A. Camus forest in Kumaun Himalaya

Sanjay Kumar* and Lalit M. Tewari

Department of Botany, D.S.B. Campus, Kumaun University, Nainital-263002, India.

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The present paper reports on the leaf litter, wood litter, miscellaneous litter and total litter fall in *Quercus leucotrichophora* forests of the Kumaun Himalaya. Peak values of leaf, wood and miscellaneous litter fall occurred in May, June and November and December respectively. The total annual litter fall was 538.85 g m^{-2}, of which leaf, wood and miscellaneous litters accounted for 72.35, 23.04 and 4.53% respectively. Monthly leaf litter fall, wood litter fall and total litter fall was positively related to the monthly temperature of the site.

Key words: Kumaun Himalaya, leaf Litter fall, wood litter fall, miscellaneous litter fall, total litter fall, seasonal variation.

INTRODUCTION

Litter fall because of its intrinsic nature to all vegetation represents an innate part in the organic continuity and the self perpetuating nature of forests, being the major pathway of nutrients return to the soil. The cycling of materials is inherent in the functioning of ecosystems and is integral to their structure and functioning. The importance of litter production has been recognised for a long period of time and consequently many studies have been carried out. Litter fall has an important influence on soil formation because it is a major component in the circulation of mineral elements and contains many complex organic compounds, which vary in biological degradability (Spain, 1973).

Mathur et al. (1982) observed that the thick layer of humus beneath the forest floor improves the infiltration rates of the forest soils. Verma et al. (1982) reported a great heterogeneity in the chemical contents of forest soil under heterogenous forest composition. Dwyer and Merriam (1981) observed that greater litter weight and depth reduced moisture loss and supported a larger bacterial population. Thus litter on the forest floor plays a significant role in determining the moisture status, runoff pattern and liberation of mineral elements accumulated in the aerial parts of the vegetation. Litter fall represents an essential link in organic production – decomposition cycle and is thus a fundamental ecosystem process (Meentemeyer et al., 1982). Proctor (1983) has argued that litter fall is relatively easy to measure and has been investigated at least for one of the following reasons: to provide an index of production; to give information (when combined with measurements of floor litter standing-crop) on decomposition rates; to give information on tree phenology, and to quantify an important pathway in mineral nutrient cycles.

Decomposition process play important role in soil fertility, in terms of nutrient regeneration and maintenance of organic matter level. The release of nutrients from decomposing leaf litter is a basic process

*Corresponding author. E-mail: sanjay14_kumar@yahoo.in.

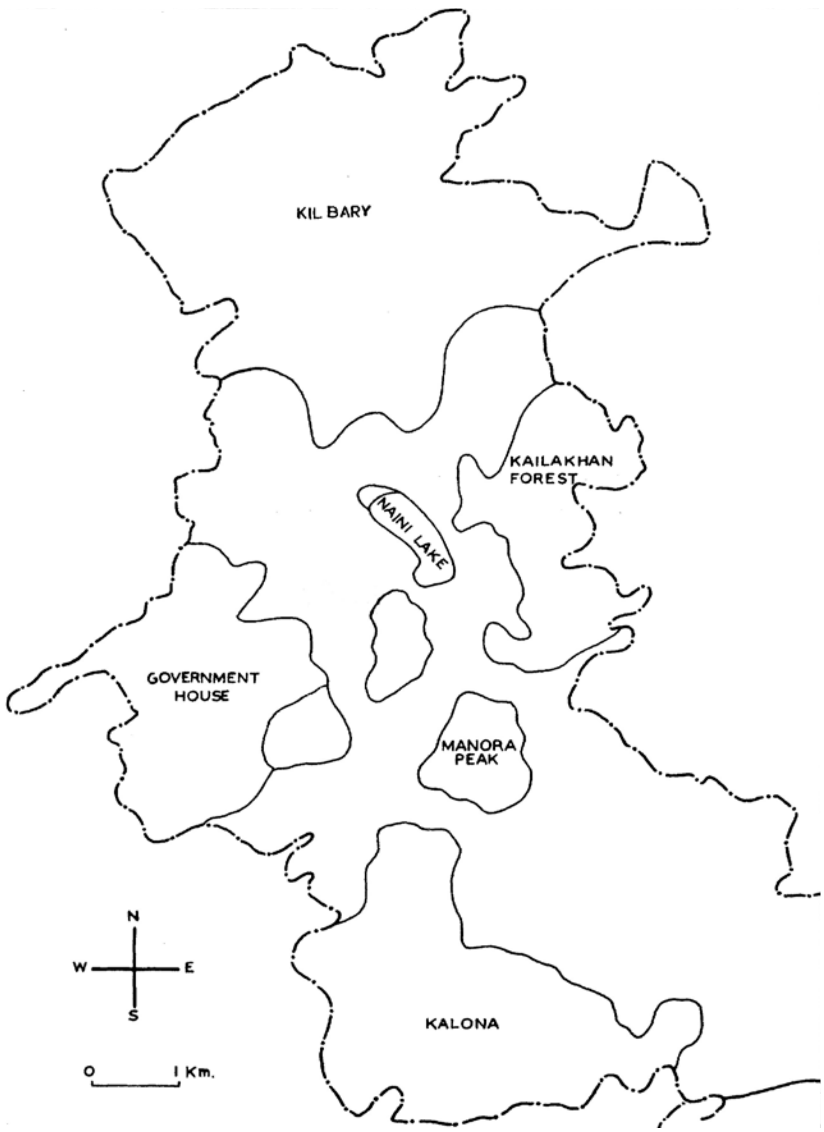

Figure 1. Location of oak forest in Kumaun study area.

in nutrient cycling within forest. Decomposition of litter is regulated by a host of variables including the litter's physical and chemical properties, habitat and macro and microfaunal responses. From 10,000 to 4,000 years B. P., *Quercus leucotrichophora* was dominant at elevation from 1,000 to 2,000 m throughout the Central and Western Himalaya. *Q. leucotrichophora* are intricately associated not only with agro-ecosystems but also with the life-support systems of the inhabitants of the hills in this area. This species is heavily used for fuel and fodder, and can be correlated with natural springs and wildlife (Singh, 1981). With increasing biotic stress, this species depleted rapidly in recent years.

The paper describes: (1) to quantify the annual litter fall and litter decomposition in *Q. leucotrichophora* forest and (2) to compare the results with those of other deciduous forests in the Mediterranean and temperate regions.

METHODOLOGY

Location

The study was conducted in Kuamun Himalaya, India (29°18'N, 79°28'E, and elevation 2200 m above mean sea level) (Figure 1). Principal site characteristics are given in Table 1. Detailed descriptions of the vegetation of this region are available in Saxena and Singh (1982), Singh and Singh (1986) and Tiwari et al. (1986).

Climate

The climate is characterized by a summer monsoon and the year has four distinct seasons namely, monsoon (July to September), post-monsoon (October to November), winter (December to

Table 1. Predominant species, mean annual rainfall, mean annual temperature, altitude and certain soil characteristics of the study site in Kumaun Himalayan forest.

Forest site/ dominant species	Total annual rainfall (mm)	Mean annual Temp. (°C)	Altitude (m)	Organic matter	Soil characteristics (0 - 30 cm depth) available				
					C (%)	Sand (%)	Silt (%)	Clay (%)	pH
Quercus leucotrichophora, Myrica esculenta, Rhododendron arboretum, Acer oblongum	2195	28	2000-2200	13.18	7.65	78.12	16.56	6.89	5.3

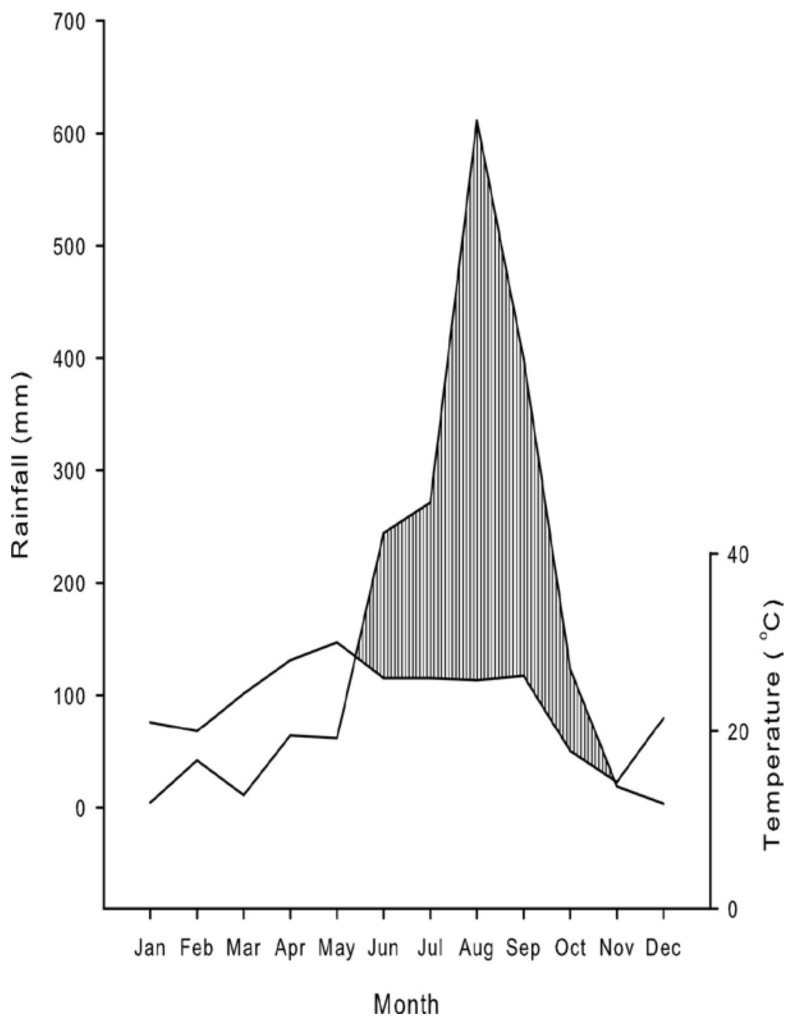

Figure 2. Rainfall and mean monthly temperature for the experimental site.

January) and summer (April to mid-June). Climatic data for 2008 to 2009 were obtained from the State Observatory at Nainital (Figure 2). The average annual rainfall is 195.87 mm of, 60% of which was occurs in the rainy season and the mean daily temperature ranges from 3.5 to 28°C.

Soils

The soils are residual, originating from slates, phyllites, sandstone, and limestone of the Krol series. Typical features of the soils of oak-dominated forests, as described by Saxena (1979), Tewari (1982), and Upreti (1982) are: (1) soils are generally brown in colour, sandy loam in texture, and slightly acidic; (2) the percentage of sand in the soil tends to decrease with increasing elevation, but is greater at disturbed than undisturbed sites; (3) soils are generally nitrogen-rich; within the same forest the nitrogen content is invariably higher on mesic hill slopes than on drier slopes. Sand predominates in the soil (60 to 80%), while the silt and clay contents are 10 to 20 and 5 to 10%, respectively. Organic matter ranges between 10.0 and 18.5% and available C between 3.2 and 8.1%, the soil pH ranges between 5 and 6 (Table 1).

For studying litter production in banj oak forest three plots of 31.5 ×

Table 2. Coefficients of correlation, slope and intercepts of the relationships between litter fall per month (Y, gm^{-2}) and mean monthly temperature (X, °C) of *Quercus leucotrichophora* forest.

Litter type	Intercept	Slope	r
Leaf	-79.30	3.776	0.873**
Wood	-11.611	0.737	0.737**
Miscellaneous	-1.01	0.107	0.803**

** Significant at P < 0.01.

Table 3 Coefficients of correlation, slope and intercepts of the relationships between litter fall per month (Y, gm^{-2}) and mean monthly rainfall (X, mm) of *Quercus leucotrichophora* forest.

Litter type	Intercept	Slope	r
Leaf	43.676	-0.241	-0.628*
Wood	13.718	- 0.076	-0.858**
Miscellaneous	1.699	0.007	0.554*

*Significant at P < 0.05, ** Significant at P < 0.01.

Table 4 Seasonal pattern of litter fall estimated through litter traps (g m^{-2} ± SE).

Season	Litter fall pattern			
	Leaf	Wood	Miscellaneous	Total
Winter	74.60 ± 2.5	29.85 ± 4.2	9.00 ± 3.2	113.45 ± 7.5
Summer	184.35 ± 12.5	45.15 ± 6.4	4.05 ± 2.1	233.55 ± 9.3
Monsoon	75.35 ± 4.7	35.30 ± 8.2	5.60 ± 1.8	116.65 ± 3.7
post monsoon	55.60 ± 3.6	13.85 ± 2.4	5.75 ± 1.3	75.2 ± 5.3

31.5 m^2 were selected on site. The litter was measured by placing five litter traps (1 × 1 m^2) on the forest floor randomly at each site. Each trap was 2 mm mesh nylon, supported by wooden sides with 25 cm height. Litter from these traps was collected separately in paper bags and brought in to laboratory where the sample was sorted out in to three main categories namely (i) leaf litter (ii) woo-den litter (<2 cm Diameter) and (iii) miscellaneous litter and dried in shade. Litter sampling study was done during May 2008 to April 2010.

The air-dried leaves were thoroughly mixed and 10 g samples were enclosed in 20 × 20 cm nylon bags (Crossley and Hoglund, 1962). Mesh size was 10 mm. Thirty six litter bags were placed on the forest floor in the beginning of the rainy season of 2008. No spatial displacement of bags due to wind action, etc. was noticed during the study. These bags were removed at monthly intervals. At each sampling time, retrieved bags were brought back to the laboratory, extra material was removed and the wet weight of the material measured. The material was reweighed after oven drying at 60°C.

RESULTS AND DISCUSSION

Litter fall

The leaf fall is greatest in the summer season (47.29%), followed by the monsoon (19.33%), winter (19.13%) and post monsoon seasons (14.26%). The contribution of leaf litter to total annual litter production was highest during summer months; the leaf litter accounted for 18.47% (May) to 12.53% (June) of the respective total monthly fall (Figure 3).

The contribution of wood litter to total annual litter production was highest during summer seasons; the wood litter accounted for 13.74% (June) to 10.14% (May) of the respective total monthly fall. The wood fall was greatest in the summer season (36.92%), followed by the monsoon (28.86%), winter (24.4%) and post monsoon seasons (9.81%).

The contribution of miscellaneous litter to total annual litter production was highest during winter seasons; the miscellaneous litter accounted for 12.3% (January) to 6.15% (December) of the respective total monthly fall. The miscellaneous fall was greatest in the winter season (36.69%), followed by the post monsoon (23.57%), monsoon (22.96%) and summer season (16.6%).

The relationship between the litter fall to mean monthly temperature and mean monthly rainfall was found significant (Tables 2 and 3). The contribution of leaf fall to total annual litter in respective month was highest during summer months; the leaf litter accounted for 78.7% (April) to 84.0% (May). The wood fall contribution was highest during monsoon months; the wood litter accounted for 31.7% (August) to 27.1% (September) and highest during winter by Miscellaneous litter. The miscellaneous litter accounted for 6.7% (December) to 19.2% (January) (Table 4).

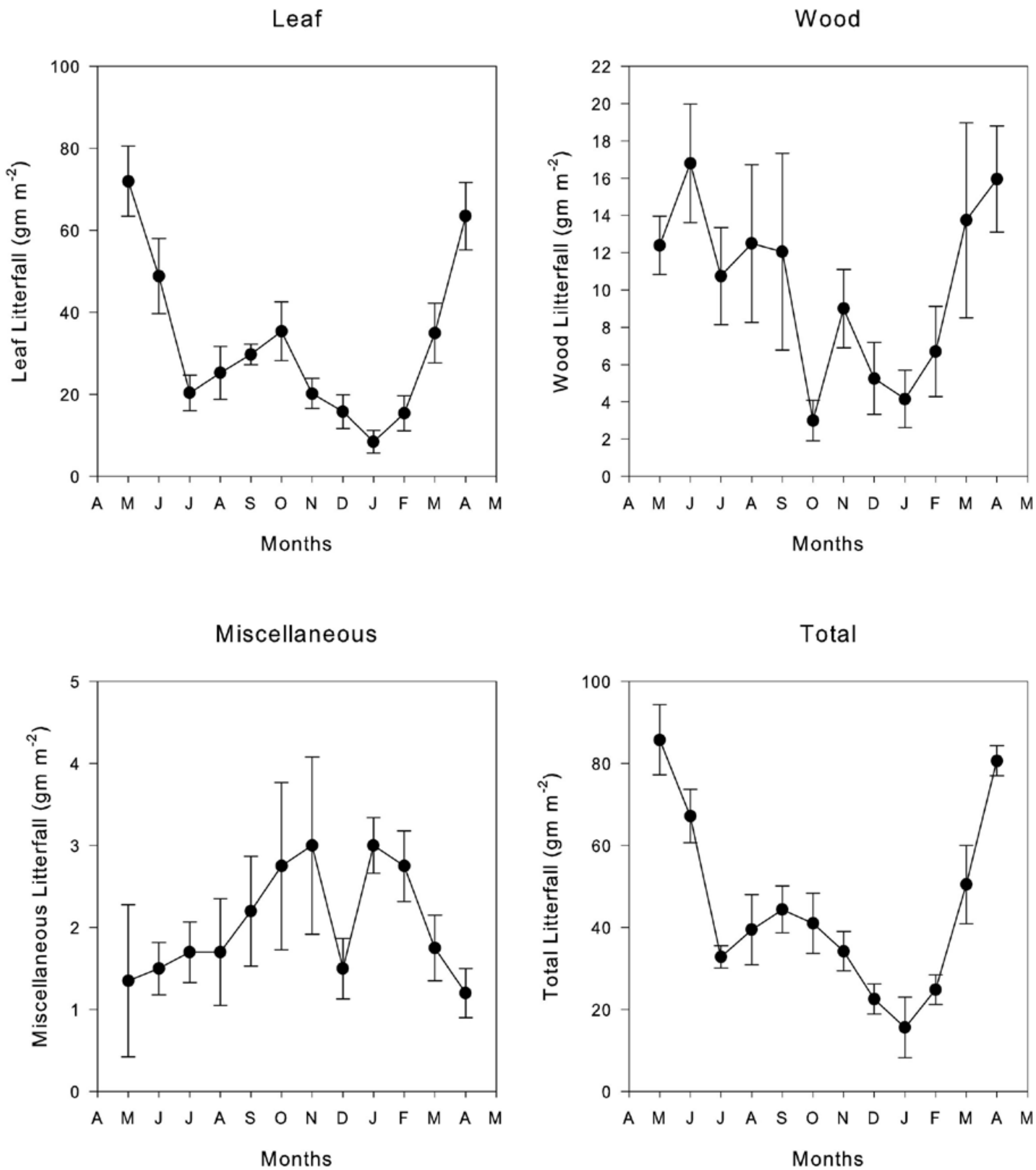

Figure 3. Monthly leaf, wood, miscellaneous and total litter fall (g m^{-2}) in banj oak forest.

Litter decomposition

Moderate temperate and abundant moisture in rainy season and higher temperature of summer season are congenial for decomposition. The loss in dry weight of oak litter during the first one year of decomposition was 67.55%, the faster decomposition rate was calculated in the month of August (10.22%) and September (9.45%). While lowest rate of decomposition was in noted in the month of May (2.11%). Singh and Singh (1984) have reported 80.45% decomposition for oak litter in 365 days. The present finding is in contradictory to the observation of Singh and Singh (1984).

The weight loss rate on each site was markedly affectted by rainfall; the weight loss per month and the rainfall per month were positively related according to the following formula:

Y = 2.048 + 0.114 X (r = 0. 0.803, d.f. = 11, P < 0.01)

Where, Y = percentage weight loss per month (%) and X = rainfall per month (mm).

Table 5. Annual litter fall values (t ha^{-1}) of some temperate and Mediterranean forests (all fractions).

Forest type	Location	Litter fall	Reference
Temperate			
Quercus petraea	England	3.86	Carlisle et al., (1966)
Q. petraea	Netherlands	6.31	van der Drift (1981)
Q. robur	Sweden	5.28	Anderson (1970)
Q. floribunda Q. lanuginosa, Q. leucotrichophora	India	4.7 - 7.8	Rawat and Singh (1989)
Q. leucotrichophora	Kailakhan	5.39	Present study
Q. cerris var. *cerris*	Northern Turkey	6.81	Kutbay and Horuz (2001)
Q. pyrenaica	Salamanca, Spain	5.62	Gallardo et al. (1989)
North American oak forests	Minnesota, USA	4.57	Reiners and Reiners (1970)
Quercus-Acer	USA	4.89	Vitousek (1982)
Quercus-Betula	USA	3.70	Witkamp and van der Drift (1971)
Acer-Fagus-Quercus	Indiana, USA	5.23	Vitousek et al.,(1982)
Alnus rubra	Oregon, USA	4.49 - 9.90	Zavitkovski and Newton (1971)
A. rubra	USA	7.80	Turner et al. (1976)
Castanea sativa	Salamanca, Spain	6.18	Gallardo et al., (1989)
Fagus sylvatica	Southern Sweden	5.70	Nihlgard (1972)
Mediterranean			
Quercus coccifera	Southern France	2.30 - 2.60	Rapp (1969)
Q. ilex	Southern France	3.80 - 7.00	Rapp (1969)
Q. ilex	France	4.22	Lossaint and Rapp (1978)
Q. ilex	Etna, Italy	3.57	Leonardi and Rapp (1981)
Q ilex	Spain	2.28	Bellot et al., (1992)
Q. ilex	Northern Spain	3.1	Mayor and Roda (1992)
Q. suber	Iberian Peninsula	2.88 - 4.33	Robert et al.,(1996)

The moisture content of decomposing leaf litter was positively related, according to the following regression:

$Y = 3.810 + 0.017\,X$ (r = 0.744, d.f. = 11, P < 0.01)

Where, Y = % weight loss per 60 days and X = % moisture content on each 60th day.

The production of litter depends primarily on the site productivity, but other properties of the environment, as well as chance, may introduce important variation. Litter alters the physical and chemical environment directly and indirectly. The physical changes produced by litter also alter the activity of decomposers, resulting in an indirect effect on the chemical environment.

Williams and Gray (1974) and Sain and Broadbent (1975) have stressed the positive effect of the moisture content on decomposition rate. The moisture content of decomposing leaf litter varied markedly on site as did the periodic weight loss. The annual litter fall value of the studied *Q. leucotrichophora* forest was 5.39 t ha^{-1}. This value is somewhat similar to the values reported from India (Table 5). With 72% percentage contribution of leaf fall to the total annual litter fall was comparable to the values reported by Singh (1992) for dry deciduous forests of India. This value is also similiar to global averages (70% for leaf litter) reported by Meentemeyer et al. (1982) and it is within the range of 40 to 85% given for temperate forests around the world by Rodin and Bazilevich (1967). A review of litter fall data for a number of temperate and Mediterranean forests is given in. In an earlier review Madge (1965) found annual litter mass values between 3.6 and 39.9 t ha^{-1} in the temperate region. Annual litter fall values of evergreen Mediterranean-type *Quercus* forests were lower than those of temperate deciduous *Quercus* forests including the studied Turkey oak forest.

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