



Weight loss patterns in decomposing litter of *Coriaria nepalensis*, an actinorhizal shrub from degraded land

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ABSTRACT

The present study deals with litter decomposition patterns in different components of *Coriaria nepalensis* Wall. Mature freshly-fallen leaves, twigs, roots and nodules of *C. nepalensis* were collected. The litter bag technique was used to assess weight loss and decay rate. Litter bags containing 5 g litter were placed under the canopy of *C. nepalensis*. Three litterbags per component were collected at monthly interval, brought to the laboratory, dried and weighed. Nodules decomposed very fast (63.9%) within 30 days followed by leaves (57.6% within 30 days) while decomposition of root was relatively slow, i.e. 53.2% within 210 days. The percent of material loss was 95.2% for nodule, 87.8% for leaves, 85.6% for inflorescence, 82.0% for twigs and 53.2% for root for entire duration. Decomposition rate coefficient (k) significantly ranged from 0.025/day (roots) to 0.101/day (nodules). The percent weight remaining was significantly affected by days elapsed, soil temperature and soil moisture.

Key words: Litter decomposition, Leaf, Roots, Nodules, Twig, Weight loss.

The decomposition of plant litter is one of the most crucial processes in the forest ecosystems (DeCatanzaro and Kimmins 1985, Shahi *et al.* 2014). It plays an important role in soil fertility in terms of nutrient cycling and the formation of soil organic matter (Bargali 1994). It is regulated by soil organism, environmental conditions and chemical nature of the litter. Litter decomposition plays a crucial role in the nutrient budget of forest ecosystem and agroecosystem where vegetation depends mainly on the recycling of nutrients contained in the plant detritus (Bargali *et al.* 2015).

C. nepalensis Wall. is a non leguminous nitrogen-fixing actinorhizal shrub or small tree with root nodule formed by *Frankia*. It is a pioneer species having ability to grow and form canopy on severely eroded hill slopes in degraded ecosystems associated with the oak forest (Joshi *et al.* 2001, Bargali *et al.* 2014). In the central Himalaya, it helps in speedy recovery of the eroded hill slopes thus show a strong effect in the harsh environment with several ameliorative effects including higher rate of soil build up accumulation of nutrient and organic matter leading to a increased soil water potential (Joshi *et al.* 2001). The purpose of this study was to determine the decomposition rates of different components in *C. nepalensis*. The major objectives were: (i) to determine the overall pattern of weight loss of decomposing litter in *C. nepalensis* and (ii) to correlate

weight loss pattern with different parameters.

MATERIALS AND METHODS

The site was located at 1900 m altitude near Nainital town (29° 22' N latitude and 19° 25' E longitude). The site was eroded steep slope (75°) covered with gravels, with little soil. At this site *C. nepalensis* occurred in patches, each surrounded by relatively large open areas with no woody plant cover. The climate of the study area is referred to as monsoon worm temperate (Singh and Singh 1992). Annual rainfall of the area was 2347 mm and the mean monthly temperature varied from 6 to 25° C during summer and 1.7 to 4° C during winter. Of the total precipitation, nearly 75% occurs during the three months of monsoon, mid-June to mid-September (Joshi *et al.* 2001). Physical and chemical characteristics of the soil in the study site are given in Table 1.

A litter bag experiment was carried out to compare decomposition rates of different components of *Coriaria*. Litter bags used in this study consisted of nylon material with a 2 mm mesh (Upadhyay and Singh 1989). The bags were of different sizes according to litter type to avoid compressing the material. Leaves, twigs, roots, nodules and inflorescence of *Coriaria* were collected from the field at the time of abscission and air dried. In total 126 litter bags (7 sampling dates × 3 replication × 6 components) were filled with 5 ± 0.01 g of air dried litter and placed on top layer soil in July. Three litter bags per component were collected at 30, 60, 90, 120, 150, 180 days intervals, brought to the laboratory where all roots, fauna and soil particles

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Table 1 Soil characteristics of the study sites (from Joshi *et al.* 2001).

Parameters	
Soil texture (0-30 cm)	
Gravel and other coarse materials (%)	75.4 ± 0.52
Sand (%)	12.1 ± 0.21
Silt (%)	8.5 ± 0.02
Clay (%)	5.9 ± 0.02
Water holding capacity (%)	25.0 ± 0.51
Soil moisture (%)	20.8 ± 0.06
Soil pH	6.1 ± 0.03
Soil organic carbon (%)	2.40
Total soil nitrogen (%)	0.37
Soil water potential (MPa)	-1.90
Soil temperature (°C)	22.8
Air temperature (°C)	
Maximum	22.4 ± 0.6
Minimum	12.7 ± 0.05

were manually removed from the litter. The dry mass of the samples in litter bags was determined after it was oven dried at 60°C to constant weight. To determine initial dry mass, three other samples of each component (not included in the above mentioned 126 samples) were weighed and dried at 60°C to constant weight. The dry mass remaining of litter of each component was calculated.

The comparison of dry mass remaining (DMR) at each sampling date, as well as among components was carried out by using ANOVA. The rate of material loss was expressed as the percentage weight remaining after a given time and was calculated by:

$$\%R = W (t_x) / W (t_1) \times 100$$

where, $W (t_x)$ is the oven dried weight (g) of the material remaining after time x and $W (t_1)$ is the initial weight of the material (Petersen and Cummins 1974).

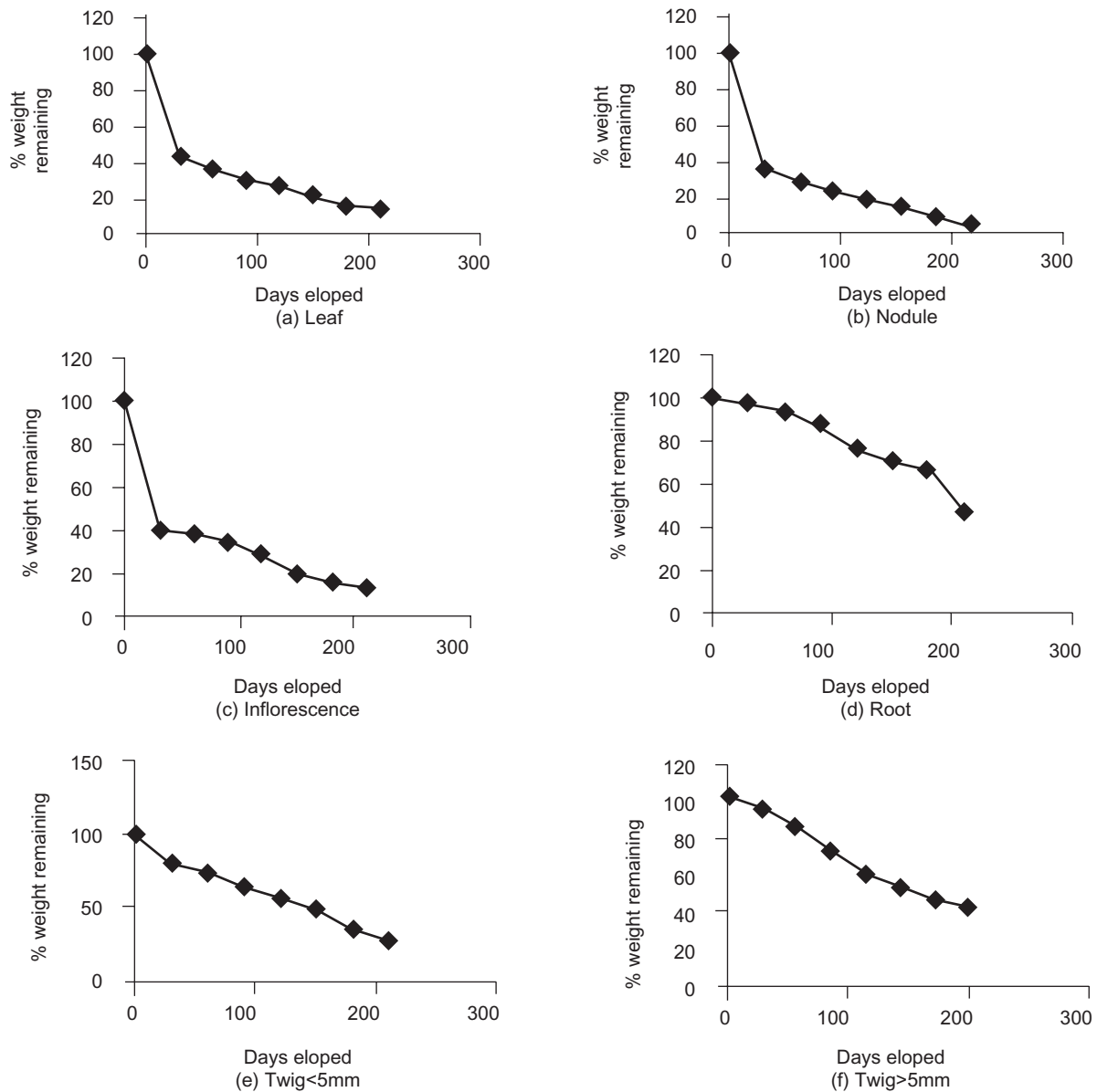


Fig 1 Percent of initial mas (even dry weight) remaining for different components over the study period

Decay rate coefficients (k) were calculated as:

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

where, t is the time in days (Petersen and Cummins 1974).The mean relative decomposition rate (RDR) was computed by using the formula:

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

where, W₀, mass of litter present at time t₀; W₁ = mass of litter present at time t₁; t₁-t₀, sampling interval (days).

RESULTS AND DISCUSSION

Weight loss in *C. nepalensis* showed significant difference due to component, sampling dates and their interactions (ANOVA; P<0.01). Loss of dry matter (% of original mass remaining) and actual weight loss per month (%), regarded as litter decomposition rate, are the two parameters used to describe the results on weight loss patterns. The rate of decomposition (%/day) at monthly interval showed the different patterns for different components (Fig 1). After 210 days, it was 1.90 %/day for leaves, 2.06%/day for nodules, 1.17-1.30%/day for twigs and 1.17%/day for roots. Upadhyay and Singh (1989) and Bargali (1995, 1996) have concluded that the rate of decomposition is markedly affected by the amount of water soluble compounds and leachable substances and nutrient content of fresh litter. In the present study, components like leaves, nodules and inflorescence showed similar pattern while twigs and roots follow almost different pattern. Overall this species showed higher decomposition rate as compared to the other species of the region (Upadhyay and Singh 1989).

Cumulative weight loss in the beginning within 30 days was maximum in nodule (64%) followed by leaves (60%) and about 95% (nodule) and 86% (leaves) over the sampling period. The weight loss in twigs and roots was relatively slow and accounted only 58% and 53% loss,

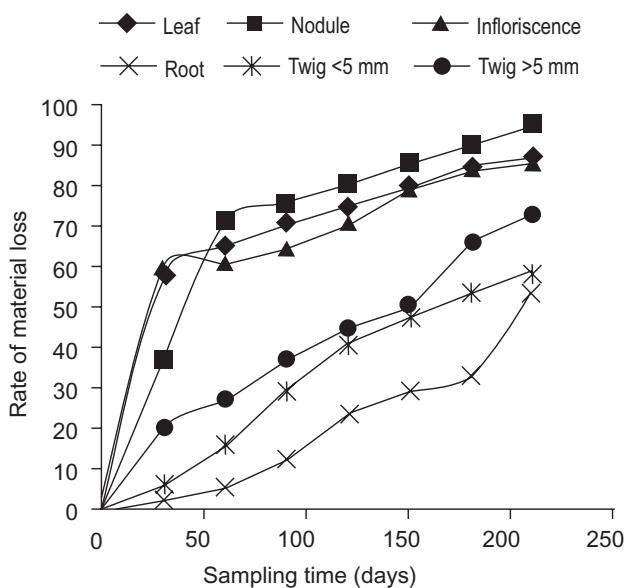


Fig 2 Rate of material loss in different component of *C. nepalensis*

Table 2 Relationship between weight remaining (WR) and days elapsed (DE), soil moisture (SM) and soil temperature (ST).

X Vs Y	Component	Intercept (a)	Slope (b)	Correlation coefficient (r)*
WR Vs DE	Leaf	45	-0.16	-0.992
	Nodule	39.78	-0.168	-0.997
	Inflorescence	47.74	-0.165	-0.978
	Root	109.38	-0.267	-0.974
	Twig< 5 mm	90.01	-0.297	-0.995
	Twig> 5mm	99.87	-0.298	-0.985
WL Vs SM	Leaf	0.32	0.7437	0.853
	Nodule	5.57	0.7272	0.862
	Inflorescence	2.94	0.5963	0.706
	Root	-15.18	0.4499	0.868
	Twig< 5 mm	11.45	0.4163	0.874
	Twig> 5mm	-5.52	0.3923	0.836
WL Vs ST	Leaf	10.24	0.4017	0.875
	Nodule	12.75	0.4006	0.901
	Inflorescence	13.8	0.2437	0.548
	Root	0.79	0.2563	0.939
	Twig< 5 mm	7.724	0.2369	0.944
	Twig> 5mm	16.29	0.2093	0.847

*Significant at p< 0.01 or 0.05

respectively across the sampling period. The rapid mass loss from nodule and leaves of *C. nepalensis* may be due to leaching of water soluble compounds (though not measured in the present study), like sugars, amino acids and soluble phenolic compounds. Wiegert and McGinnies (1975) have shown a highly significant effect of litter type on the disappearance rate in Puerto Rico rain forest.

Except roots and twigs percent weight remaining patterns were similar for rest of the components (Fig 2). Although weight loss was continued throughout the study period, relatively highest weight loss occurred within the initial 60 days (July-September). High soil moisture and optimum temperature during rainy season could have facilitated greater growth in microbial population that could induce faster decomposition. Gupta and Singh (1977) have shown highest disappearance rate 36-53% during rainy season, while weight loss of 15-26% was recorded in winter

Table 3 Decay rate coefficients (-k) of different component in *C. nepalensis*

Days elapsed	Component					
	Leaf	Nodule	Inflorescence	Root	Twigs <5 mm	Twigs >5 mm
30	0.028	0.034	0.031	0.0008	0.002	0.008
60	0.017	0.021	0.015	0.0009	0.003	0.005
90	0.014	0.016	0.011	0.0014	0.004	0.005
120	0.011	0.014	0.010	0.0022	0.004	0.005
150	0.010	0.013	0.010	0.0023	0.004	0.005
180	0.010	0.013	0.010	0.0022	0.004	0.006
210	0.009	0.014	0.009	0.0036	0.004	0.006

Table 4 Relative decomposition rate (g/g/d) of different component in *C. nepalensis*.

Days elapsed	Component					
	Leaf	Nodule	Inflorescence	Root	Twigs <5 mm	Twigs >5 mm
30	0.028	0.034	0.031	0.0008	0.0076	0.0021
60	0.0065	0.0077	0.00036	0.0010	0.0030	0.0036
90	0.0056	0.0055	0.0033	0.0025	0.0046	0.0057
120	0.0050	0.0010	0.0063	0.0044	0.0043	0.0060
150	0.0029	0.0096	0.0077	0.0025	0.0042	0.0040
180	0.0090	0.0127	0.0084	0.0019	0.0119	0.0042
210	0.0056	0.023	0.0132	0.0119	0.0082	0.0034

season. Higher weight loss in rainy season was possibly due to favourable microbial activity and temperature (Bargali *et al.* 1993, 2006, Usman *et al.* 2000). There existed a negative relationship between percent weight remaining and time elapsed for all components (Table 2). The climatic conditions were markedly different during various months, therefore, the relationship between climatic variables (temperature and rainfall) and percent weight remaining were developed using simple correlation and regression analysis. The results obtained have been given in Table 2. Both the parameters (soil moisture and temperature) showed significant positive correlation with percent weight remaining of each component.

The decay coefficient for each component is given in the Table 3. It was maximum for nodule (0.013–0.034) and minimum for roots (0.0008–0.0040). The monthly relative decomposition rate (RDR) ranged between 0.003 and 0.028 g/g/d for leaves, 0.001 and 0.034/gg/d for nodule, 0.003 and 0.030 g/g/d for inflorescence, 0.003 and 0.008 g/g/d for twigs and 0.004 and 0.006 g/g/d for roots (Table 4). The decomposition rate were usually greater during rainy season, possibly due to pronounced microbial activity under favourable temperature and moisture conditions and accentuated leaching due to rainfall (Pandey and Singh 1982, Singh *et al.* 1990).

Thus, the planting of *C. nepalensis* is going to cause the quantitative change in the restoring of the degraded hill ecosystems due to its high decomposition rate. Since the soils of the hill ecosystems are relatively more vulnerable to erosion losses, plantations of this species is likely to recover the ecosystem a relatively faster rate and could facilitate the growth of other species.

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